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APPLIED MECHANICS REVIEWS

VOL. 13, NO. 7 JULY 1960

SHIP VIBRATION

Part I: Propeller-Generated Excitations

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INTRODUCTION

Vibration of ship hulls and substructures has been of vital interest to naval architects and marine engineers for a long time. In recent years, problems associated with vibration have come to command major consideration because of increase in the power to be absorbed by the propeller(s) in driving all types of modern ships to higher speeds.

This is the first of a two-part review of the state of knowledge of ship vibration. Part II, dealing with the elastic response of the ship structure to vibratory forces and moments will be presented by R. T. McGoldrick of the David Taylor Model Basin in the August 1960 issue of *Applied Mechanics Reviews*. As the title implies, the present article is related to the efforts made to date in the study of the blade-frequency pressure and velocity field near ship propellers, the vibratory forces generated on nearby surfaces and the cyclic variations of thrust and torque developed by ship propellers operating as they do in the strongly nonuniform flow field at the stern of vessels. It is hoped that, by understanding these effects, means can be found to reduce the exciting forces and hence to reduce vibration materially. Since the generation of exciting forces arises in two distinct (but not inseparable ways) i.e., through the action of the blade-frequency (b–f) field, and the generation of fluctuating bearing forces attending thrust and torque variations, it is reasonable to separate the review into these two main categories, although some of the experimental work has involved the determination of both hull surface forces and bearing forces.

BLADE-FREQUENCY PRESSURE FIELD EFFECTS

Although serious vibration at shaft frequency (once per revolution) can be obtained, it has largely been eliminated through the use of rotationally balanced turbine-gear and shaft systems. Consequently, almost all objectionable vibration of ship structures is found to occur at blade frequency (number of blades times the shaft revolutions) or higher harmonics of that frequency. Credit for initiation of the first serious study aimed at a determination of the blade frequency forces and torsional moments is due to the Council of the Society of Naval Architects and Marine Engineers (SNAME). With their support and the very material assistance of the United States Experimental Model Basin (then operated by the Bureau of Construction and Repair, Navy Department), Professor F. M. Lewis devised and carried out experiments on a 20-foot model of the twin-screw S.S. President Hoover. The first report on these studies appeared (1) in 1935. In brief, Lewis's method consisted of detecting the vibration of the model by an electrical pick-up tuned to blade frequency. The response of the model was next determined by applying known blade-frequency forces in the plane of the propellers. Measurements were also made with the propellers supported from shafts running from a trailing model in order to obtain the effect of the surface forces alone without the contribution of the bearing forces. These results showed that the surface forces were nearly the same as the total forces, which implied that the bearing forces were very small, and furthermore that these surface forces decay very rapidly with relatively small increase in the axial clearance of the propellers. To illustrate the nature of the blade-frequency pressure (b–f, p) distribution on a flat plate, Lewis (1) constructed an electrical field by means of a search coil. This gave an approximate picture of the blade-frequency pressures on a flat wall (twice the magnitude of free-space pressures) in the form of contours of constant pressures which allowed some rough estimates of force to be made. Unfortunately, after all the labor of constructing the electrical analogy, Lewis did not vary the distance of the imaginary wall or plane in which the search coil was moved and hence did not obtain the vitally important information on the influence of tip clearance on the magnitude of pressures and force. The electric analogy also suffers from the fact that it represents only part of the total field, as is now appreciated. In the same paper, Lewis gave a calculational scheme for computing the vibratory bearing forces obtained as a result of the propeller operating in an irregular wake and also digressed to consider the mean effect or thrust deduction about which he drew misleading concepts because of an overly simplified mathematical model. In retrospect, this paper and the one which followed in 1936 (2) made large steps forward in learning much about this phenomenon, but suffered from the lack of a complementary theoretical approach of broad scope.

During the period 1935–1951, virtually nothing of note was accomplished to further knowledge of the subject (with the exception of some theoretical work done in Russia as will be noted below). At that time (1951) the David Taylor Model Basin (TMB) revived interest in the subject and, with the moral support and guidance of SNAME's Hydroelasticity Panel (H-8), launched a program to develop an experimental technique

which would be practical to use with regularly employed models. For various reasons, TMB researchers were not able to use F. M. Lewis's technique and set out to develop a method along somewhat different lines. No formal report of these developments is yet available, but a paper is expected in the Fall of 1960 which should relate that a feasible method of measuring horizontal and vertical forces and torsional moments on 20-foot single-screw models has been evolved.

In 1954, J. Hadler at TMB realized the need for basic measurements of propeller pressure fields to complement the development of technique for measuring hull surface forces and, accordingly, initiated experiments under the direction of Dr. H. Lerbs and A. Tachmindji to measure the b-f field around a propeller model in a water tunnel (3). To assist in the interpretation of these data, a theoretical study by Breslin (4) was supported by TMB. In that work, the pressure field about a three-bladed propeller was developed from simple vortex line representation, the b-f constituent being found by numerical methods. Included in Reference (4) is a study of the effect of a translating two-dimensional foil section (modeled by a single vortex) on a flat plate which represented alternately a skeg and a rudder. This solution, which was secured by using linearized aerodynamic concepts, showed a remarkable difference in the lateral force on the plate, depending on whether it is upstream (skeg) or downstream (rudder) of the section. A slow decay of the force with axial clearance was found due to the two-dimensionality of the flow and to the over-simplified modeling of a blade section by a single vortex. A "semi-three-dimensional" problem was also attacked (4) by using the velocity field of only the vortex bound to the rotating blade, situated directly abaft a flat plate of infinite span. A solution obtained by using "strip theory" showed much stronger attenuation of lateral force with axial clearance.

The vortex representation was shown (5) to be consistent with the zero Mach number limit of the near field aerodynamic analyses of Watkins and Durling (6) whose work represented an extension (to include the effect of forward speed) of the study of Gutin (7) on aircraft propeller noise. It should be noted that Gutin did not evaluate his theory in the near field which is of importance in naval architecture. Another interpretation is to be found in Reference (8), where representation of a propeller blade as a helicoidal sheet of doublets extending to infinity in the wake allows insight into the relationship between the velocity potential and the pressure or acceleration potential of a narrow-bladed propeller.

A carefully conducted, scholarly analysis by S. Tsakonas (9) showed that the harmonic analysis of the pressure field can be written in terms of elliptic integrals, thus removing the necessity for numerical methods. His re-examination of the calculations reported in Reference (4) disclosed numerical errors in that work and revealed that all of the foregoing mathematical models were inadequate to explain pressure-field measurements either in character or in magnitude. Up to this point, the thrust and torque loadings on the blades were accounted for, but the blades were considered to be of zero chord (with exception of (6)) and without thickness. Rough explorations of the influence of finite chord only showed greater departures from the data. The writer proposed to include blade thickness on the basis that the contribution of thickness distribution to the minimum pressure on a section is about equal to that due to camber at designed angle of attack. An approximate allowance for thickness was made and shown (9) to explain both the nature and magnitude of test data. Moreover, very simple formulas obtained by elementary expansions were shown (9) to fit the data well and reveal dependence on the various parameters.

The inclusion of blade thickness was anticipated by R. Arnoldi who has not reported his analysis in the "open" literature (10). Russian work on this subject (knowledge of which has only recently been obtained) predates all of the theoretical work done in the U.S.A. Two of Babayev's papers (11, 12) can be read without recourse to other generally unavailable Russian papers. His results provide a formula for the total fluctuating pressure due only to thrust and torque (do not include thickness effects) and do provide expressions for the b-f components. He does consider the influence of inclination of the propeller axis to the plane of the wall (12). Reference (13), on the effect of cavitation in the near field pressures, is incomprehensible.

Returning to experimental techniques, F. M. Lewis and A. J. Tachmindji (14) discussed both model and full-scale methods of estimating such vibratory forces and couples and presented model test results to show that their amplitudes are large; vertical force (single amplitude) 6% of mean thrust, transverse force on hull 16%, and hull couple 70% of mean shaft torque. Full-scale vertical force from Old Colony Mariner was found to be 7% of mean thrust, thus corroborating the model test. Other facets of the data were not, however, easy to understand. At the Admiralty Experimental Works (AEW), Haslar, England, Ramsey (15) has made a "broad brush" analysis of the propeller field using Gutin's work. Interesting experimental work to measure surface forces on a model at AEW is underway. F. M. Lewis is currently completing a study of the vibratory forces on a strut mounted ahead of a model propeller in a water tunnel. This work shows a sizeable vibratory force and the manner in which it changes with axial clearance. At this time, no reports are published.

The best experimental study to appear to date has just been brought to light in the very recent paper by H. Pohl (16) at the Hamburische Shiffsbau Versuchanstalt (HSVA), who reports pressure measurements in the vicinity of five propeller models. Three of the models were selected to show effect of number of blades and two for the effect of diameter. Pohl inserted pressure gages in the wall of a water tunnel and varied the distance of the propellers from the wall.

By this simple device he doubled the magnitude of the free space pressures and hence obtained greater accuracy in the measurements. Variations of the blade-frequency pressure with axial, radial and athwartship distance are reported and compared with theory. It is shown that the vortex theory alone is insufficient to explain these data and that much better agreement (although not satisfactory everywhere) is had by using the theory given in (9). He also installed pick-ups on two ship models and obtained interesting comparisons of pressures with those obtained on the tunnel wall. Comparison with TMB data (3) shows relatively good check on peak amplitudes but the TMB curves show much more irregularity than do those of the HSVA. Pohl points out that additional studies are necessary to understand the competitive roles of wake flow (which increases the pressures) with respect to the uniform flow along a plate. In regard to the influence of number of blades, the HSVA data show the change in b-f, p reduces in proportion to the increase in number of blades in changing from 3 to 4 blades, but a greater rate of decrease is obtained in going from 3 to 5 blades. Happily, the study of the influence of diameter on the dimensionless results showed no effect as expected from theory or dimensional analysis. Much needs to be done with Pohl's data in regard to correlation with a complete theory as many of his comparisons were made with respect to the vortex theory which is known to be incomplete. It is hoped that the large advance made through these systematic studies at HSVA will encourage wider experimentation in this country.

A broad program of theoretical and experimental exploration of b-f, p and effects on nearby structures is being initiated by Silverleaf and Carmichael at the Hydrodynamics Laboratory, Ship Division, National Physical Laboratory in Feltham, England. Here it is planned to study the field about 12 propellers, some of which will be selected to verify the influence of blade thickness. Preliminary (unpublished) results show strong promise of being very useful.

The field near a counter-rotating propeller is currently being studied by Tsakonas at the Davidson Laboratory to assess the advantages of such propellers in regard to vibratory pressures. The blade-blade interaction in this case presents a difficult problem to evaluate.

Latest theoretical efforts to obtain an estimate of the magnitude of surface forces have been directed toward finding the b-f force on a doubly infinite flat plate parallel to the axis of rotation. H. Pohl (17) found (by integrating the total pressure induced by a single blade) the force for two or more blades to be zero, and the answer for a single blade to be one which could be arrived at by statical considerations. J. Breslin (18) concurrently derived the same result in different ways but showed that, even if the force is zero, an elastic plate will vibrate under such pressure loading since the vibrational response does not depend on the integral of the pressure distribution. It now appears possible to invert the process heretofore used, i.e. now to first determine the b-f pressure at any point on the plate and then to integrate that over the plate. This now appears to give a non-zero result which is most interesting as it contradicts previous analyses and provides a means for assessing the importance of vibratory surface forces on a theoretical basis.

A large effect for which no answers are yet available is that due to nonuniformity of inflow due to the relatively thick boundary layer at the stem of all large ships. The pressures in the near field (as well as the loading on the blades) may be expected to vary sharply from what has previously been computed for uniform inflow. These additional effects are currently under study.

VIBRATORY THRUST AND TORQUE

Many practical naval engineers regard the mitigation of vibratory thrust or longitudinal vibration as the most important problem in ship vibration. There has been an active study of this effect in Germany, in the Netherlands and in the U.S. The German studies (19) and (20) appear to be limited to approximations based on estimates of the quasi-steady propeller forces. Work at the Netherlands Ship Model Basin under van Manen has been concentrated on the development of new, highly accurate means of measuring variable thrust, torque and shaft bending moments on propellers operating in variable wakes. Some results obtained on models having unconventional stem arrangements have shown much reduced vibratory thrust (21). Similar determinations have been made by W. Book et al. (22), (23) and by Krohn (24), (25) in Germany.

On the theoretical side, there does not exist an entirely rational theory for the unsteady thrust (and torque) developed by a propeller working in a wake. Timman and van Manen (26) (as reported by Van Lammeren) appear to be the first to appreciate that the flow about the blade elements is unsteady and must not be treated as though it were steady-state. They applied an aerodynamic analysis which treated each section as though it were performing heaving and pitching oscillations. Ritger and Breslin (27) more properly regard the sections as wing elements "flying" through a gust pattern which is made up of many harmonics (in terms of angular position). The aerodynamic solution to this motion is applied stripwise to show that blade-frequency thrust variations depend only on that harmonic of the wake distribution and, moreover, that the influence of unsteadiness is large, giving a much smaller predicted vibratory thrust than from quasi-steady calculations. The singling out of blade harmonics has also been observed by Schuster (20) and others. Unfortunately, it has not been possible to secure a set of reliable data against which the theory can be checked.

Since only wake harmonics at blade frequency (and integer multiples) can influence the magnitude of thrust vibrations, it is doubtful that model tests can presently be relied upon to give close estimates for a ship. The NSMB has shown (28) a large variation in mean wake with Reynolds number (from measurements on models ranging from 8' to 60' long). A 48-point numerical harmonic analysis of these wakes made by the writer reveals an even stronger variation in the various dimensionless harmonic coefficients with model size, although the variation is not in the direction expected. More accurate means of measuring wake will be necessary and, moreover, much more full-scale data will be necessary in order to know how to adjust the boundary layer on a ship model to give wakes having the correct harmonic content.

Methods for damping propeller-generated bearing and hull forces have been developed with considerable success by Grim of HSVA. Installations on the survey ship NORD(29) are described as having made striking reductions. A novel feature is the fitting of a rubber plate backed by an airtight box directly over the propeller. A sizeable reduction in sound and vibration level was found.

It seems safe to say that we are now on the threshold of a period in which the combined experimental and theoretical research on this subject will reveal very definite means which the designer can employ to reduce markedly the exciting forces and hence to make a large change in ship vibratory amplitudes. Both theory and experiment have shown that large reductions are possible with relatively small increases in axial clearance and that the benefit of increased tip clearance is relatively small. The theory now allows estimates (in the case of twin-screw ships) of the reduction in the magnitude of blade-frequency pressures with increase in the number of blades, and (re) this effect is not simply inversely proportional to the number of blades for the same thrust.

The skeptic may say that many of these things were known intuitively by designers for many years. That is true. What naval architects have not had is a means for assessing the worth of a design change for the sake of vibration abatement. This is important since each change or design concept involves many compromises. It may now be expected that because of the increased research activity on the exciting forces produced by a propeller, techniques and charts will become available to provide the designer of modern ships with a rational basis for making decisions.

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Analytical Methods in Applied Mechanics

(See also Revs. 3236, 3237, 3239, 3244, 3245, 3261, 3263, 3286, 3287, 3288, 3316, 3317, 3323, 3430, 3484, 3494, 3665, 3694, 3729, 3741)

3218. Christeller, S., Finding the roots of a fourth degree equation by splitting into quadratic factors (in German), *ZAMP* **10**, 5, 525–527 (Brief Notes), Sept. 1959.

A simple method for the solution of an equation of the fourth order consists of splitting the equation into the two quadratic factors, each of which then can be solved separately.

M. M. Stanisic, USA

3219. Marcus, M., Basic theorems in matrix theory, Nat. Bur. Stands., Applied Math. Series no. 57, 27 pp., Jan. 1960.

This is a valuable compendium on the subject. It is a list of numerous results on the subject (without proof), and provides a handy reference for research workers and students. Some of the topics covered are basic definitions and elementary theorems, canonical forms, determinants, eigenvalues, linear equations, inequalities and condition numbers. This is a must on every applied worker's book shelf. In fact, at the low price (15¢), one can easily find use for at least two copies.

Y. L. Luke, USA

3220. Stiefel, E., Discrete and linear Tschebyscheff approximations (in German), *Numerische Mathematik* **1**, 1, 1–28, Jan. 1959.

Consider the system $\sum_{i=1}^{m} a_{ji}x_i + c_j = 0$, $j = 1, 2, \ldots, n$, $n > m$. Suppose value of left-hand side of above equation is b_j for various points x in m-space. The problem is to find that point for which $\mathrm{Max}|b_j|$ is a minimum. This is the classical Tschebyscheff problem solved by De La Vallee-Poussin in 1911. Present attack leads to a more efficient algorithm for numerical solution. An example of the computational procedure is provided.

Y. L. Luke, USA

3221. Chow, T.-S., and Milnes, H. W., Boundary contraction solution of Laplace's differential equation. Part II, *J. Assn. Comput. Mach.* **7**, 1, 37–45, Jan. 1960.

For Part I, see AMR **12**(1959), Rev. 4264. Present paper investigates relation that must exist between mesh sizes in the circumferential and radial directions to guarantee convergence of the procedure.

Y. L. Luke, USA

3222. Milne, W. E., and Reynolds, R. R., Stability of a numerical solution of differential equations. Part II, *J. Assn. Comput. Mach.* **7**, 1, 46–56, Jan. 1960.

In Part I [see AMR **12**(1959), Rev. 4270] it is shown that instability in Milne's method of solving a single differential equation of the first order can be avoided by occasional use of Newton's "three eights" rule. In the present paper, the analysis is extended to higher-order systems of equations. Four numerical examples are presented.

Y. L. Luke, USA

3223. Gol'denveizer, A. L., Asymptotic integration of partial differential equations with boundary conditions depending on one parameter, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 5, 922–942, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Let L be a linear partial differential operator of order n with variable coefficients in two independent variables α, β. Author considers problems of the following types. PROBLEM A: suppose n is even and L is elliptic in a simply connected domain Γ with boundary γ. Let Φ and certain of its derivatives be prescribed as rapidly oscillating functions of position on γ, the frequency of oscillation characterized by a large parameter k. Find an asymptotic expansion for Φ for large k if $L\Phi = 0$ in Γ. PROBLEM B: Suppose L is totally hyperbolic with n distinct families of real characteristic curves. Let Φ and certain of its derivatives be prescribed as rapidly oscillating functions of position on an initial curve γ which is nowhere tangent to any characteristic curve of L, the frequency of oscillation characterized by a large parameter k. Find an asymptotic expansion of Φ for large k if $L\Phi = 0$. PROBLEM C: For an operator L of any type, find an asymptotic expansion for large k for a particular integral of $L\Phi = \Psi(\alpha, \beta) \exp [kf(\alpha, \beta)]$.

Author describes a procedure for obtaining such expansions in k to any prescribed order. The determination of these expansions depends on the solution of the first-order nonlinear partial differential equation for the characteristics of L and a sequence of first-order linear partial differential equations. The Cauchy problem (Problem B) for the hyperbolic case is related to earlier work of Lax [*Duke Math J.* **24**, 4, 627–646, 1957].

J. K. Knowles, USA

Book—3224. Mikusinski, J., Operational calculus, Vol. 8 (Translated from the second Polish ed.), New York, Pergamon Press, Inc., 1959, 495 pp. + diagrams and bibliography. $15.

See AMR **10**(1957), Rev. 3157.

Book—3225. Comolet, R., Introduction to dimensional analysis and to the problems of similarity in fluid mechanics [Introduction à l'analyse dimensionnelle et aux problèmes de similitude en mécanique des fluides], Paris, Masson et Cie, Editeurs, 1958, 116 pp. 1.600 F. (Paperbound)

First half of book is devoted to fundamentals of dimensional analysis and to their application in determining nondimensional variables for problems of fluid mechanics. Second half presents the notions of geometrical, kinematical, and dynamical similitude and then discusses their application to various problems (incompressible flow without and with a free surface, compressible flow, cavitation, turbomachines, etc.). A discussion of the relations between similitude and dimensional analysis is also included. Book is illustrated with a series of photographs of hydraulic models.

Reviewer, after careful reading, has come to conclusion that there is a great danger of being mislead by this introduction to two important topics in fluid mechanics. Many passages are obscure, others lack in rigor, and quite a few seem to lead to wrong conclusions.

In a subject with so few theorems, they should be proved, or at least a sketch of the proof should be given. The author chooses not to prove the π-theorem and not to give the main conclusion in the right way: "The π-theorem shows that the number of dimensionless variables is p-q (p number of dimensional variables, q number of fundamental units). P. W. Bridgman showed in 1922 that this rule is not infallible. Under different forms an exact rule has since been given by several authors, but we will adhere to the original one" (p. 33).

Reviewer does not understand concept and purpose of reducing number of fundamental units to zero. Author, after reducing the fundamental units of mechanics to one (length), says: "This last arbitrary unit can also be made to disappear. For example, consider the atomic structure and make the Planck constant of unit value, then for the corresponding system of units, $q = 0$: every arbitrary fundamental unit has thus been eliminated" (p. 17).

Examples of obscure statements are: "Dimensional analysis is a method of calculation much more refined than algebraic calculus" (p. 1). "If the motion is steady the corresponding streamlines are geometrically similar curves" (p. 58), thus implying that they are not similar for unsteady motion. "The use of reduced (nondimensional) variables in the equations permits a closer approach to the physical phenomena, because they do not need to be measured to exist" (p. 65).

Reviewer has read some interesting and rather complete books and papers on dimensional analysis and similitude, and finds little justification for following statements: "French and foreign publications, most of the time, are only limited presentations applied to particular problems".... "Rare are the works covering this question (similitude) in a general way or at least defining with accuracy its domain of validity" (p. 1).

E. O. Macagno, USA

3226. Senju, S., The optimal assignment of repairmen in serving automatic machines, *Bull. JSME* **2**, 5, 65-74, Feb. 1959.

Author considers problems associated with a single operator whose task consists of walking among N machines and making minor repairs when required. Time spent in walking is assumed large relative to time required for machine repair. Equally likely machine failures, Poisson processes, exponential distributions of failure times, and other elementary probability concepts are applied. Problems studied include optimal location of operator when not servicing a machine, expected walking distance between successive machine repairs, arrangement of machines to minimize expected walking distance, and systematic versus unsystematic patrolling among machines. Some results correlate data associated with an operator in charge of 25 weaving machines in a spinning mill where machine repair consists of repairing broken threads.

Although reviewer believes author's results have limited theoretical significance, the results exemplify the application of basic probability methods in an engineering context.

R. E. Thomas, USA

3227. Lowell, H. H., Tables of the Bessel-Kelvin functions Ber, Bei, Ker, Kei and their derivatives for the argument range 0(0.01) 107.50, NASA TR R-32, 300 pp., 1959.

Self-checking digital and tabulating equipment was used for calculation of the tables. For ber, bei, ber′, and bei′, the number of significant figures is either 13 or 14 for the two absolutely larger functions but is generally less for the remaining two. For ker, and so forth, the number of significant figures varies from a minimum of 9 for the absolutely largest function at arguments near 9 to a maximum of 14 elsewhere; 13 or 14 is achieved for all arguments greater than 14. The number of significant figures for the remaining three functions of the second kind is in general less at a given argument than for the absolutely largest function.

From author's summary

Computing Methods and Computers

(See also Revs. 3240, 3243, 3262, 3264, 3269, 3281, 3287, 3466, 3534, 3657)

3228. Ostrowski, A. M., On the convergence of the Rayleigh quotient iteration for the computation of the characteristic roots and vectors. Parts 3 and 4: Generalized Rayleigh quotient and characteristic roots with linear elementary divisors; Generalized Rayleigh quotient for nonlinear elementary divisors (in English), *Arch. Rational Mech. Anal.* **3**, 4, 325-347, Aug. 1959.

This work is an extension of parts I and II under the same title. In part III, author gives a generalization of the Rayleigh quotient iteration method for the computation of characteristic roots and vectors of n by n nonsymmetric real and non-Hermitian matrices for the case where the elementary divisors corresponding to a single or multiple characteristic root are linear. In part IV, author gives a quadratically convergent iteration rule for computing a characteristic root of an n by n matrix to which a nonlinear elementary divisor corresponds. This part generalizes a rule given in part I for n by n real nonsymmetric matrices. [see AMR **12** (1959), Rev. 5356, and AMR **13** (1960), Rev. 552 for parts I and II.]

J. Jones, Jr., USA

3229. Takeyama, H., Expressions for interpolation and numerical integration of high accuracy, *Technol. Rep. Tohoku Univ.* **23**, 1, 47-70, 1958.

Formulas for interpolation and integration of a function of one real variable using polynomial approximations agreeing with the function and its first (n-1) derivatives at m uniformly spaced points are derived. High accuracy means a truncation error related to the 2nth derivative. Tables are given for interpolation at 99 equally spaced points within the interval for the cases $n = 2$ to 4 with two points and interpolation at 9 such points for $n = 16$ and $m = 2$. Coefficients for numerical integration are given for the cases $n = 1$—7 with $m = 2$ and $n = 2$ with $m = 2$—6. Examples include the numerical solution of a fourth-order differential equation describing the lateral vibration of a tapered beam.

Reviewer believes some of the work duplicates that in other sources; e.g., H. E. Salzer, *J. Math. Physics* **34**, p. 103-112, 1955.

C. L. Perry, USA

Analogies

(See also Revs. 3442, 3461, 3514, 3630, 3721)

3230. Svensson, N. L., An electric analogue for the limit analysis of framed structures, *Struct. Engr.* **37**, 10, 292–298, Oct. 1959.

A d-c analog was constructed utilizing the electrical-structural relationships in which voltage is proportional to deflection, current proportion to load, and flexibility proportional to resistance. Network elements were designed with current-voltage curves that have the same shape as stress-strain curves. This permitted investigation of nonlinear structures including buckling and plastic deformation, as a result of which the electrical system could be used for limit analysis. The investigation of a single-panel redundant truss yielded agreement of theory and the network results within 5% on the average. H. Becker, USA

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 3281, 3300, 3352, 3417, 3664, 3668, 3679, 3680, 3702)

Book—3231. Leech, J. W., Classical mechanics, New York, John Wiley & Sons, Inc., 1959, ix + 149 pp. $2.50.

This very valuable monograph presents in a concise form the classical principles of mechanics on the advanced level. Special emphasis and extensive treatment have been afforded to the Lagrangian and Hamiltonian formulations, to their physical meaning and applicability to higher tenets of mechanics and theoretical physics. Variational principles, Transformation theory, Continuous systems and fields complete the impressive list of contents of this scholarly book, written with clarity and dignified simplicity. Though chiefly of interest to the theoretical physicist, it will be highly regarded for advanced research and study in applied mechanics, considering the general tendency for breaking away from the trivial viewpoint in favor of treatment of the subject-matter from the vantage point of general principles.

The book is not for the beginner; but it will be appreciated for research work and studies of advanced nature.

J. Mandelker, USA

Book—3232. Hunt, K. H., Mechanisms and motion, New York, John Wiley & Sons, Inc., 1959, xiv + 114 pp. $4.25.

Book presents the fundamentals of kinematics. After introductory chapters (1, 2) which explain basic problems of the subject and the elements of vector methods used in kinematics, some general principles governing the relative motion of rigid bodies (Chap. 3) are studied. Chapters 4, 5, and 6 concern the analysis of plane mechanisms, including also sliding and higher pairs and considerations about degrees of freedom, suppression of freedom, constrained motion and substitute mechanisms. Simple useful methods which help to establish the geometrical form of mechanisms are given. The last chapters (7, 8) deal with advanced problems of space mechanisms and direct the reader to understand further geometrical principles of a more general character as applied to plane motion.

Book is provided with many illustrative figures and exercises, which enable the student to obtain a detailed understanding of the subject. It can be recommended as a very good up-to-date introductory textbook on kinematics.

V. Kopriva, Czechoslovakia

3233. Agostinelli, C., On the rolling motion of a nonhomogeneous disk (in Spanish), *Cienc. y Tecn.* **127**, 638, 164–169, May 1959.

Author obtains in scalar form the equations of motion of a nonhomogeneous heavy disk rolling on a perfectly rough horizontal plane. A similar, but simpler, problem (homogeneous disk) is mentioned in classical treatises [See, for instance, Sect. 244 of Routh's Treatise, AMR **8** (1955), Rev. 3286].

G. Capriz, England

3234. Marsicano, F. R., Movement of a point of variable mass attracted toward a fixed point by a Newtonian force (in Spanish), *Cienc. y Tecn.* **127**, 638, 170–182, May 1959.

Author studies the title problem with perturbation methods, considering the effect of the variation of mass on the motion of the point as due to a small perturbing force. He assumes the unperturbed motion to be Keplerian and goes on to determine the secular variations of the elements of the orbit (inclination, nodes, major axis, etc.) under rather arbitrary conditions: he takes the relative speed of the lost mass to be proportional to the absolute speed of the mass point and the mass to decrease linearly and very slowly with time. G. Capriz, England

3235. Sapa, V. A., The equations of motion of a system of material points in a variable mass in generalized coordinates (in Russian), KazSSR, The Classical Equations, Izv. Akad. Nauk KazSSR. Ser. Math. i Mekh. no. 6(10), 60–81, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9484.

An investigation is made of the motion of a system of N material points in a variable mass, in which the masses of the points vary due to simultaneous emission and absorption of particles.

For such a system with holonomial linkages, on the assumption that the masses of the points therein are functions only of time, equations of motion are obtained in the form of Lagrange equations. Particular cases and examples are discussed.

Further, for a system in the same conditions but with linear instead of holonomial linkages, equations of motion are derived in generalized co-ordinates with indeterminate factors, as well as the corresponding Appel equations.

Finally, the equations of motion are reduced to the classical form.

It must be pointed out that for the case of a system in which the mass changes only by the emission of particles, the equations of Lagrange and the classical equations have been derived by A. A. Kosmodemiansky. M. I. Efimov

Courtesy Referativnyi Zhurnal, USSR

3236. Iglisch, R., Resonance concept in linear ordinary differential equation of the second order (in German), *Arch. Rational Mech. Anal.* **3**, 3, 179–186, Mar. 1959.

Author proves the following theorems: In the differential equation $y'' + a(t)y' + b(t)y = f(t)$ let a, b, f be periodic functions of t with the common period P. The equation $z'' - az' + (b - a')\,z = 0$ is called the adjoint equation of the given differential equation. If there are no periodic solutions z with the period P, then there exist bounded solutions y for all values of t, i.e. the uniquely determined periodical solution y with the period P. If there are periodical solutions z with the period P for which $\int_0^P z(t)f(t) = C \neq 0$, then for every solution y there exist values which are numerically greater than any arbitrarily assigned number when $t \to \infty$. This is the case of resonance. If $C = 0$ there exist bounded solutions y for all values of t, i.e. the periodical solutions with the period P depending now on one or two parameters.

J. Lense, Germany

3237. Iglisch, R., Resonance concept in nonlinear ordinary differential equations of the second order (in German), *Arch. Rational Mech. Anal.* **3**, 3, 187–193, Mar. 1959.

Author proves the following theorems: In the differential equation $y'' + g(y, y', t) = f(t)$ let $g(y, y', t + P) = g(y, y', t)$ and $f(t + P) = f(t)$ for all values of t. It is assumed that g, its partial derivatives of the first and second order and f are continuous functions. Let $y(t)$ be a periodical solution of the differential equation with the period P. We consider now the equation $u'' + g(y + u, y' + u', t) - g(y, y', t) = \beta F(t)$, where $|\beta|$ is sufficiently small and $F(t + P) = F(t)$, and the homogeneous linear differential equation $\varphi'' + g_{y'}(y, y', t)\varphi' + g_y(y, y', t)\varphi = 0$. If this equation has no periodical solutions $\varphi(t)$ with the period P, then there exist solutions $u(t)$ with $|u(t)| \leq \text{const } |\beta|$ for all values of t, i.e. the uniquely determined periodical solution with the period P. If there is a solution $\varphi(t)$ so that $p(t)\varphi(t)$ has the period P, where $p(t) = \exp(\int g_{y'}, (y(t), y'(t), t)\,dt$ and $\int_0^P F(t)p(t)\varphi(t)\,dt \neq 0$, then for every solution there exist values with $|u(t)| \geq \text{const}\sqrt{|\beta|}$ for $t \rightarrow \infty$. This is the case of resonance.

J. Lense, Germany

3238. Sawaragi, Y., Fujii, T., and Okada, Y., Forced vibrations of the system with two degrees of freedom with Coulomb damping, *Bull. JSME* **2**, 6, 311–317, May 1959.

Analysis is made of motion under a harmonic disturbing force of a two-mass system suspended by springs when there is constant friction between the masses or between one mass and support. Theoretical solutions, with or without stops, appear to agree with experimental observations made by authors.

G. Power, England

3239. Shen, C.-N., Stability of forced oscillations with nonlinear second-order terms, *ASME Trans.* **81** E (*J. Appl. Mech.*), 4, 499–502, Dec. 1959.

Author considers the differential equation:

$$d^2(Y + \beta Y^2)/dt^2 + Y = \beta G \cos pt \qquad [1]$$

where p, G and β are constant, β is small. By classical methods he obtains the first and second approximations for the periodical solution (of frequency p) of [1] and the boundary of its stability. He gives too the first approximation of the more general equations:

$$d^2(Y + \beta Y^2)/dt^2 + Md(Y + \mu Y^2)/dt + Y = G_1 \cos pt + G_2 \sin pt \qquad [2]$$

where M, β, G_1, G_2, μ are small. Equation [2] defines the behavior of some tanks with feedback controller.

D. Graffi, Italy

3240. Lehnigk, S., On the structural stability of a certain class of linear motions, AGARD Rep. 194, 15 pp., Apr. 1958.

Paper solves a mathematical question from the algebraic field with applications to several stability problems of stationary motions.

By considering the problem of the structural stability of polynomials $f(p) = g(p) + h(p)$, previously examined by M. A. Aizerman and F. G. Gantmacher, author gives for the first time a complete solution for the case in which h is a polynomial of at most second degree. For this purpose a necessary and sufficient condition theorem is proved.

The structural stability, an idea which to the reviewer's knowledge was introduced by I. I. Galperin in 1940 [*Izvestia VTI* no. 6, 1940], represents a potential stability of the investigated stationary motion. Its existence gives a first indication of the possibility of obtaining a stable motion by an adequate choice of the constructive or kinematic parameters.

The reviewed paper solves the problem for cases which offer interesting applications in several domains. Two examples of flight mechanics are included. The first one discusses the possibility of stabilizing the longitudinal motion of an aircraft with variable c.g. location by means of a longitudinal automatic control system of linear characteristic, if the control parameters follow adequately the c.g. shift. The second example considers the disturbed motion with controls locked by using the undisturbed flight velocity as the unique parameter of the system. Thus the analysis is considerably simplified and indicates that the dynamic stability range coincides with that of structural stability and covers the whole given variation interval of the parameter.

T. Hacker, Roumania

3241. Ryder, F. L., and Zaid, M., Landing-gear vibration instability, *J. Aero/Space Sci.* **26**, 5, 303–309, May 1959.

Analysis applies to interplay of gear deflection and slip of nonskidding braked wheel. Slip is inserted in equation of motion through empirically related ground contact force, which leads to third-order, essentially nonlinear, equation. Small disturbance stability analysis indicates instability below a certain forward speed when braking torque versus wheel angular speed has negative slope, probably the common case. Result is interesting in that it clarifies important property of the complex dynamics of the braking process. Further results are obtained through numerical integration of basic equation. They indicate that conditions may exist which provoke wheel blocking upon application of brakes. Experiments are recommended to ascertain adequate numerical parameter data.

J. H. Greidanus, Holland

3242. Schjelderup, H. C., The modified Goodman diagram and random vibration, *J. Aero/Space Sci.* **26**, 10, p. 686 (Readers' Forum), Oct. 1959.

Instrumentation and Automatic Control

(See also Revs. 3240, 3698)

3243. Rosenbrock, H. H., Interconverting frequency and transient response, *Control Engng.* **6**, 7, 116–120, July 1959.

The described graphical method for interconverting two kinds of responses into each other is based on the semilogarithmic plotting of the transfer functions and trigonometric functions. The form of the trigonometric functions remains the same and should be only shifted for various values of time instants under consideration. The method is greatly facilitated by the use of the special cursor and graph papers which have been made commercially available.

The accuracy in evaluating the transient response data from frequency response is very satisfactory, while the errors in inverse conversion are largely due to the restrained amount of information in the transient response about the behavior of the system at the higher frequencies.

M. Mesarovic, USA

3244. Hilscher, K., Computation of the time function (in German), *Automatisierung: Z. Messen, Steuern, Regeln* **2**, 1, 33–36, Feb. 1959.

Author outlines a method of calculating the transient function if the transfer function (frequency response) is given. The method is based on the approximate calculation of the roots of the characteristic equation. Author has the opinion that the transient function better describes the particulars of the control system (stability, quality, etc.) than, for instance, the "evasive" method of transfer function. The only example he sketches does not convince the reviewer.

W. Hahn, India

3245. Gonnermann, H., A method for solving algebraic equations (in German), *Regelungstech.* **7**, 2, 53–56, Feb. 1959.

The analytical treatment of control loops with linear elements leads to differential equations with constant coefficients. A new numerical evaluation requires the determination of the roots of the

algebraic equation, whereby, however, the calculating effort increases steeply with increasing order. A simple graphical method is suggested for equations of the fourth order, which is suitable for the determination of all real and complex roots.

From author's summary

3246. Hofmann, R., A criterion for the existence of multiple roots or of an even or odd number of conjugate complex pairs of roots in algebraic equations (in German), *Regelungstech.* **7**, 9, 310–312, Sept. 1959.

It is shown how, for rational polynomials, the square of the product of the differences of the roots can be obtained closed by means of the coefficients. This product gives a clue to the existence of at least one multiple root and it also indicates whether the number of conjugate complex pairs of roots is even or odd.

From author's summary

3247. Peterka, V., A simple numerical method for calculating the transfer function on linear control systems (in German), *Regelungstech.* **7**, 2, 47–52, Feb. 1959.

Information is provided with respect to a simple numerical method for calculating the transfer function of linear control systems based upon the differential equations of the system or upon the transient (dynamical) coefficients. It is also applicable where dead time or pure lags exist. This method renders it possible to determine the transfer functions of a closed loop control system if the characteristics of the open loop networks are known. These may have been found by practical measurements on the controlled plant and the controller.

From author's summary

3248. Strejc, V., Method of approximation for aperiodic transfer characteristics (in German), *Regelungstech.* **7**, 4, 124–128, Apr. 1959.

A delay system of higher order with equal time constants is suggested for the approximation of experimentally determined aperiodic transfer characteristics of controlled plants. A method is described, applicable to controlled plants whose transfer function belongs to the class of delay systems of the second order, which allows the time constants to be determined with sufficient accuracy.

From author's summary

3249. Euler, K., Control systems with transportation time lags (in German), *Regelungstech.* **7**, 3, 89–92, Mar. 1959.

The behavior of control systems with transportation time lags is studied by measurements on a model. The demand for control systems with the shortest possible response time is particularly dealt with. The electrical analog of the controller, which was developed for this purpose, is described. With this analog the lag time is obtained by means of an LC-ladder (delay line), and the kind of control system is simulated by an electrical four-pole. Several tests are described. The I-B-system for controlling plants with transportation delay, found by these analog investigations, shows particularly short response times.

From author's summary

3250. Schliessmann, H., The optimum setup for control systems with dead time (in German), *Regelungstech.* **7**, 8, 272–280, Aug. 1959.

The transient response of the deviation resulting from a step disturbance of the output of a controlled plant has been calculated for several types of control loop containing dead time, using exponential series of the Laplace transform. The results have been used to determine the settling time corresponding to the prescribed tolerance limits.

A thorough investigation of the general integral control system leads to the conclusion that the ideal integral system does not represent the optimum system for a control loop with dead time. For each finite tolerance limit ε there is a value $\alpha < 1$ which enables shorter settling times to be obtained. Settling times following a step disturbance will be shortest if a PI system is used. A reduction of the settling time either by the use of derivative action or second-order integral action is stated to be impossible.

If it is required to smooth out slow periodic fluctuations or to correct for irregular disturbances, there is no more favorable arrangement for a control loop with dead time than a second-order PI system.

From author's summary

3251. Schliessmann, H., A method for the optimum control of systems with dead time (in German), *Regelungstech.* **7**, 12, 418–421, Dec. 1959.

Author studies the behavior of a proportional controller with feedback in a control loop having dead time. If the feedback is designed to be an analog of the controlled plant and provided the controller is suitably dimensioned, it should be possible to compensate for a step disturbance occurring at the output end of the controlled plant after no more relay than the dead time, without overshoot. The drawbacks and limitations of this method are discussed.

From author's summary

3252. Becker, H., Contribution to the theory of multiple control (in German), *Regelungstech.* **7**, 4, 133–134, Apr. 1959.

The approach to a problem relating to the theory of multiple control, treated by Kavanagh in a general manner, is investigated by means of a special formulation. The analysis and synthesis of an individual system is demonstrated on an individual example on the basis of the derived equations.

From author's summary

3253. Hajek, J., Simplified criteria for the stability of linear control systems (in German), *Regelungstech.* **7**, 5, 170–174, May 1959.

Simplified conditions are stated for the stability of linear dynamic systems up to the eighth order. Methods for the derivation of such criteria for systems of any order are described. The criteria arrived at, as shown in this article, render it possible to determine the coefficient required to guarantee the stability of the systems, an example quoted being a case where only limited means of damping are available.

From author's summary

3254. Tschauner, J., The stability of a control system of a special kind (in German), *Regelungstech.* **7**, 7, 247–248, July 1959.

A control system the regulating unit of which has a definite undamped frequency and in which the signal transmission is continuous is frequently unstable. The present investigation, however, proves that the same system will become perfectly stable if the signal transmission is made intermittent. It is thus demonstrated that intermittent signal transmission (impulse regulation), under certain conditions, is a suitable means for improving the stability of a control system.

From author's summary

3255. Hofmann, R., A method for the numerical calculation of the original functions from the given component describing functions (in German), *Regelungstech.* **7**, 8, 269–271, Aug. 1959.

A method is shown which enables the original function of a component describing function to be expressed in the form of a series, thus eliminating the laborious determination of the roots of the denominator polynomial. An example illustrates how well the derived series converges.

From author's summary

3256. Starkermann, R., The mutual influence of the controlled variables in multiple control loop system (in German), *Regelungstech.* **7**, 9, 301–306, Sept. 1959.

The stability of a system containing a dual control loop is investigated with the help of a simple example selected from the wide field of systems with multiple control loops. These consist of a number of idealized proportional controllers, each feeding one regulating unit, so that mutual coupling between the control loops

can take place only within the controlled plant. The system stability is determined for a specified amount of coupling in the controlled plant. From author's summary

3257. Imlay, F. H., A nomenclature for stability and control, David W. Taylor Mod. Basin Rep. 1319, 61 pp., May 1959.

A general purpose nomenclature is presented for dealing with problems in stability and control of surface ships, submarines, torpedoes, and towed bodies. The nomenclature is essentially an extension of the nomenclature for submerged bodies that was adopted by the American Towing Tank Conference in 1948. The need for the revision has been brought about by the numerous new techniques that have been introduced in the interim, and by the desire to develop a uniform nomenclature to cover all classes of stability and control problems dealt with by the Stability and Control Division at the David Taylor Model Basin.

From author's summary

3258. Savinov, G. V., and Tsitovich, P. A., A particular linear dependent system (in Russian), *Vestn. Mosk. In-ta, Ser. Matem., Mekhan., Astron., Fiz., Khimii* no. 3, 9-12, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9506.

The method of Van der Pol is used to solve the equation of an undamped harmonic oscillator with uniformly increasing frequency. The transition to an irregularly rotating system of co-ordinates in the phase plane permits a solution of the abbreviated Van der Pol equations in cases where the modulus of the derivative of the changing frequency is less than the modulus of the frequency itself at any given time instant. A. S. Alekseev

Courtesy Referativnyi Zhurnal, USSR

Book—3259. Lur'e, A. I., Some nonlinear problems of the theory of automatic control [nichtlineare Probleme aus der Theorie der selbsttatigen Regelung], (Translated from the Russian, 1951), Berlin, Akademie-Verlag, 1957, xi + 167 pp. DM 15.

Before comenting on this book it is useful to say a few words about its importance to the control theory. As is well known, the existing (linear) theory makes use of Laplace's transformation, which simplifies control problems by reducing them to algebraic equations instead of differential equations (d.e. for short); this is permissible, however, as long as problems are linear. With a gradually increasing importance of nonlinearities, the use of this transform theory becomes less justified.

The work of Lur'e constitutes the first step in the return to the nonlinear d.e., avoiding the use of transforms and of everything else which goes with them (e.g. transfer functions, amplitude-phase diagrams, etc.). In his book Lur'e establishes a linear transformation reducing the d.e. of the control theory to *the canonical form*, owing to which the application of the second method of Lyapunov to the investigation of stability is facilitated. This should be regarded as a fundamental achievement which gave rise to numerous researches in this direction.

Coming more specifically to the contents of the book, in Chapter I are given the fundamentals of the Lur'e transformation leading to the canonical equations; a number of examples illustrate this transformation. Chapter II constitutes perhaps the essence of the book, namely, the application of the second method of Lyapunov to the d.e. reduced to the canonical form. Chapter III deals with the question of self-excited oscillations, considered again in terms of the canonical equations. Beginning of this chapter uses the analytical argument but, beginning with 10, nonanalytic cases are considered.

The last chapter, IV, concerns some special problems in the theory of stability, in particular those in which the operating point (in the parameter space) happens to be near to the border line (or surface), separating the region of stability from that of instability.

Although the book is written in a condensed manner, it represents a very complete source of information for those who wish to become acquainted with this new trend in the theory of automatic regulation and control; numerous examples facilitate this task.

N. Minorsky, France

3260. Krug, E. K., and Minina, O. M., Optimal transients in an automatic control system having a bounded regulator unit, *Automation and Remote Control* **19**, 1, 8-20, Jan. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 1, 10-26, Jan. 1958 by Instrument Society of America, Pittsburgh, Pa.)

The forms of the optimum transients in automatic control systems are determined for those with objects of various response characteristics (including delays), assuming the control valve to be position bounded. It is shown that there are difficulties in using continuous-action regulators to produce optimal transients, because the nonlinear converters to the regulators must have responses determined by the magnitude and site of the perturbations, and by the initial values of the bounded co-ordinates. Stepwise operated regulators are proposed for use in obtaining optimal transients. From authors' summary by H. D. Block, USA

3261. Popov, V.-M., Relaxing the sufficiency conditions for absolute stability, *Automation and Remote Control* **19**, 1, 1-7, Jan. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 1, 3-10, Jan. 1958 by Instrument Society of America, Pittsburgh, Pa.)

The sufficiency conditions for absolute stability are investigated in the case of automatic control systems which contain a servomotor with a nonlinear speed characteristic. It is shown that it is possible to relax these conditions in certain cases. In particular, necessary and sufficient conditions are obtained for three cases (except for intractable special cases).

From author's summary by H. D. Block, USA

Book—3262. Feinstein, A., Foundations of information theory, New York, McGraw-Hill Book Co., Inc., 1958, x + 137 pp. $6.50.

Author's research contributions to the mathematical theory of information theory, particularly to the coding theorem, are well known to mathematicians working in this field. At the time this book was written, there was no single source presenting a unified and rigorous treatment of the mathematical theory, and this book went far toward rectifying that situation. Subsequent research findings now call for another effort in this direction and further books will probably be forthcoming.

This book will offer hard reading for most engineers. Although brief sketches of such topics as Borel Fields, Measure Theory, Probability Spaces and Lebesque-Stieltjes Integrals are provided, most engineers will find their mathematical background insufficient to digest this text without considerable effort. It should be clearly understood that this is a book on *mathematical foundations*; not an *introduction to the theory and practice*.

The chapter headings indicate the topics covered: (1) Introductory concepts; (2) Basic properties of H(X); (3) The discrete channel without memory; (4) The coding theorem for discrete channels without memory; (5) The semi-continuous channel without memory; (6) The discrete channel with memory; and (7) The binary symmetric channel. H. D. Block, USA

3263. Schlitt, H., Statistical methods used in control engineering (in German), *Regelungstech.* **7**, 1, 11-18, Jan. 1959.

A brief review of some standard statistical concepts followed by two applications, one in control and one in filter theory. No mention is made of the powerful dynamic programming approach [R. Bellman, "Dynamic programming and stochastic control processes," *Information and Control*, **1**, pp. 228-239, 1958].

R. Kalaba, USA

3264. Milsum, J. H., Statistical optimization of regulators employing a binary error criterion, *ASME Trans.* **81** D (*J. Basic Engng.*), 2, 254-262, June 1959.

Author treats a "go-no-go" performance criterion for control systems that have saturation-type nonlinearities. No penalty is assigned if error is within tolerance; constant penalty is assigned if error exceeds tolerance. Performance is measured by the proportion of time during which error is within tolerance. When subject to stochastic signals of Gaussian character in amplitude and frequency, author shows the limitations of statistical linearization. Main difficulty is in predicting error amplitude distribution. Using Gaussian and chi-squared approximations, results from analog computer study can be bracketed. General qualitative results are what can be expected using conventional linear methods, but quantitative differences are large.

Reviewer believes that work is novel and useful to a limited extent. The criterion used is quite restricted for general control application and one should be careful in extending the results to other situations. Familiarity with statistical communication theory is needed for proper understanding of the paper.

L. A. Gould, USA

3265. McKee, J. W., Single-degree-of-freedom simulator investigation of effects of summing display-instrument signals on man-machine control, NASA TN D-148, 30 pp., Dec. 1959.

A limited study has been made, using analog computing equipment, of a man's ability to control "on instruments" an inertia with a proportional acceleration control. A single-degree-of-freedom system was simulated, and, at times, in order to increase the difficulty of the task, unrealistic disturbance inputs and system instability were used. The study was undertaken to evaluate performance obtained with the indicator responding to displacement and with anticipation provided by adding velocity and acceleration signals to the indicator.

The summing of displacement and velocity signals improved performance and had the effect of providing system damping. The addition of an acceleration signal was beneficial in some instances but was destabilizing in the absence of a velocity signal.

From author's summary

3266. Nightingale, J. M., Servo feedback systems, *Mach. Design* **31**, 17, 155–159, Aug. 1959.

Complex problems in analysis of servo systems can be simplified by using three helpful tools:

1. Circuit diagrams, similar to those used in electrical circuits, in which displacement and force are analogies of voltage and current.

2. Resolution of practical element into "ideal" elements together with additional elements which represent losses, friction, and other passive elements.

3. Matrix and transfer-function algebra to determine required system characteristics, such as displacement transfer-functions and input and output impedances.

From author's summary

Book—3267. Kirillow, I. I., Automatic control of steam and gas turbines [Regelung von Dampfund Gasturbinen] (Translated from the Russian), Berlin, VEB Verlag Technik, 1956, 395 pp. DM 30.

Although modernized by including newer concepts on stability, steady-state and dynamic errors, etc., the main course of the book is firmly based on the original work of Stodola and Wyschnegradski. Book is written for students and practicing engineers, therefore mathematical treatment is uncomplicated and clear. Book's main importance lies in the detailed technical and constructional description of the control systems and components (in which the experiences of many decades are reflected) and the process dynamics of the turbines with associated equipment. References deal mostly with Russian papers and installations, so that book is very useful for comparison purposes.

R. G. Boiten, Holland

3268. Rechberger, H., A quasi-modulating turbine control system for small hydraulic power plants (in German), *Regelungstech.* **7**, 1, 2–5, Jan. 1959.

Stepwise controls generally require less expenditure on apparatus than equivalent modulating controls. The advantage of two-point controls (small error) and of the integral three-point controls (possibility of stable conditions) can be combined. This can be proved mathematically, assuming a switching-period sufficiently small in comparison to the time constant of the controlled plant. The applicability of such a control is shown in connection with the voltage control of small hydraulic power plants, where even a brief overshoot of the desired value should be avoided. The plant and the control apparatus become particularly simple if the voltage is produced in capacitor-excited asynchronous generators.

From author's summary

3269. Ellingsen, W. R., and Ceaglske, N. H., Control-system for a chemical process by the root-locus method, *AIChE J.* **5**, 1, 30–36, Mar. 1959.

Paper illustrates the application of the root-locus method in the design of a control system for a theoretical stirred tank reactor. Controlled variables are concentration and temperature. Basic process equations are linearized and solved after transformation for such values of constants which produce either stable or unstable steady-state reactor condition. Control of reactor is then possible by feedback loop regulation of one or more of four adjustable variables. Block diagram is considered for the case of regulation of one of these variables, namely the flow of water through cooling coil, and for this system the determination of the closed loop roots of the characteristic equation by means of the root-locus method is described. The case of unstable steady state is investigated in fair detail for proportional, proportional-integral and proportional-integral-rate modes of control. Relative merits of various root-locus diagrams are analyzed from the point of view of satisfying general response specifications, and technical conclusions are drawn. Experimental verification of computed results is not given.

Agnes H. Zaludova, Czechoslovakia

3270. Fanning, R. J., and Sliepcevich, C. M., The dynamics of heat removal from a continuous agitated-tank reactor, *AIChE J.* **5**, 2, 240–244, June 1959.

3271. Kalinin, P. D., and Kuznetsov, A. K., Programmed temperature regulation, *Instruments and Experimental Techniques* no. 1, 152–153, Apr. 1959. (Translation of *Pribory i Tekhnika Eksperimenta, USSR* no. 1, 136–138, Jan./Feb. 1958 by Instrument Society of America, Pittsburgh, Pa.)

3272. Summerfield, M., Control of solid propellant burning rates by acoustic energy, *ARS J.* **29**, 10, 791–792 (Tech. Notes), Oct. 1959.

This note presents the idea that acoustic energy beamed on the burning surface of a heterogenous solid propellant may enhance the normal burning rate by a significant factor, if the frequency and power level are sufficiently high. The theory is based on the concept of a steady-state combustion zone incorporating a granular diffusion flame, as described by the author in an earlier publication. It is speculated that acoustic stirring would hasten the gaseous reaction rate in the thin flame layer, raise the energy feedback to the surface, and so increase the burning rate. Since acoustic stirring would have its maximum effect on an unmixed diffusion flame, it is expected that heterogeneous propellants would respond more than homogeneous types. The author has no experimental verification of the idea as yet, but experiments are under way.

From author's summary

3273. Gillespie, W., Jr., Eide, D. G., and Churgin, A. B., Some notes on attitude control of earth satellite vehicles, NASA TN D-40, 80 pp., Dec. 1959.

The problem of matching satellite mission stabilization requirements with attitude-control-system capabilities is investigated. The probable civilian missions in an advanced satellite program and a variety of possible satellite stabilizations systems are considered. On the basis of this study it appears that most of the mission requirements can be initially met. In particular, an improved version of spin stabilization incorporating earth-horizon scan units is attractive for meteorological payloads. Attitude-control systems employing radiation-sensing units should be developed. Such systems can be quite versatile in meeting performance requirements with adequate useful life and moderate weight and power. They are also compatible with the launching vehicle guidance capability. From authors' summary

3274. White, M. D., and Schlaff, B. A., Airplane and engine responses to abrupt throttle steps as determined from flight tests of eight jet-propelled airplanes, NASA TN D-34, 39 pp., Sept. 1959.

In conjunction with a generalized landing-approach investigation, airplane and engine dynamic responses to abrupt throttle movements were determined. The thrust responses of the engines and the corresponding acceleration responses of the airplanes are presented. The relationship of these responses to pilots' ratings of airplane approach characteristics is indicated.

From authors' summary

3275. Stodola, E. K., Radio guidance, *ARS J.* **29**, 12, 940-945, Dec. 1959.

3276. Fried, W. R., Doppler radars for guidance-design techniques and performance, *ARS J.* **29**, 12, 957-967, Dec. 1959.

3277. Powell, R. W., Infrared trackings, *ARS J.* **29**, 12, 973-980, Dec. 1959.

3278. Rodriguez, E., Method for determining steering programs for low thrust interplanetary vehicles, *ARS J.* **29**, 10, 783-788, Oct. 1959.

A simple method is presented for determining possible thrust vector programs to transfer a low thrust space vehicle between coplanar circular orbits. A two-body physical model and constant vehicle thrust-to-mass ratio are assumed. Through relations between specific energy and specific angular momentum, this method determines possible steering programs and avoids the costly, difficult, time-consuming trial and error processes of computing numerous trajectories to arrive at a possible steering program. Simple examples of steering programs with their machine-computed trajectories illustrate the method.

From author's summary

3279. Pine, C. C., Performance criteria for aircraft localizer guidance systems, *Aero/Space Engng.* **18**, 9, 43-45, 66, Sept. 1959.

The concept of establishing a standard lineal deviation sensitivity, at a specified point on the approach, for aircraft localizer guidance systems at all instrumented airports is given. The operational advantages accruing from this standardization are outlined.

A statistical treatment of the system errors is presented, and, finally, an equation is derived which permits evaluation of the lateral guidance system performance. From author's summary

3280. Mundo, C. J., Jr., Trade-off considerations in the design of guidance equipment for space flight, *Aero/Space Engng.* **18**, 6, 31-34, June 1959.

3281. Statsinger, J., Theory and instrumentation of inertial navigation systems, *SAE Trans.* **67**, 463-468, 1959.

Paper is a brief tutorial review of the methods of design and operation of inertial navigation systems. A brief history of navigation introduces the basic theory of inertial techniques which is followed by a discussion of the gyros, accelerometers and computing elements that make up the navigation system.

Reviewer feels that, although not novel, the paper is an excellent short review of the subject. L. A. Gould, USA

3282. Kel'zon, A. S., and Grigor'eva, O. V., Proportional navigation as a problem of cybernetics, *Soviet Phys.-Doklady* **3**, 4, 756-760, Apr. 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **121**, 3, 432-435, July-Aug. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.).

3283. Westbrook, C. B., The pilot's role in space flight, *Aero/Space Engng.* **18**, 11, 51-54, 67, Nov. 1959.

Man's basic capabilities as a control element—an actuator, sensor, computer, and a part of a complete control system—are discussed and conclusions formed as to his strong and weak points and his possible uses in a space mission.

From author's summary

3284. Kinney, W. L., Analysis of electrohydraulic pressure control servo-valve performance and loads, ASME Instruments and Regulators Conf., Cleveland, Ohio, Mar.-Apr. 1959. Pap. 59-IRD-9, 11 pp.

Elasticity

(See also Revs. 3300, 3302, 3307, 3312, 3316, 3317, 3323, 3340, 3353, 3354, 3366, 3386, 3393, 3397)

3285. Schaefer, H., The stress functions of the three-dimensional continuum; static explanation and boundary values (in German), *Ing.-Arch.* **28**, 291-306, Mar. 1959.

In the plane problem of the theory of elasticity, in the problem of thin plane plates as well as in the problem of thin shells, the stress functions and their derivatives on the boundary are obtained as stresses in a fictitious rod along this boundary subjected to external loads.

These properties are extended to the case of the three-dimensional linear theory of elasticity for a single-connected homogeneous isotropic body without initial stresses. The stress state is represented with the aid of a symmetrical tensor of the stress functions which has six independent components. The boundary conditions are set in stresses. It is thus proved that the stress function tensor coincides on the boundary of the three-dimensional region with the moment tensor of the thin shell which bounds the body subjected to external loads, if a stress function tensor which leads to a zero stress state is neglected. Results are given in Cartesian coordinates both for the elastic parallelepiped and the elastic half-space, and in cylindrical coordinates for the case of the rotation symmetry.

Reviewer believes that the ideas expressed in this paper may lead to interesting mathematical formulations of some particular three-dimensional problems of the theory of elasticity.

P. P. Teodorescu, Roumania

3286. Morley, L. S. D., On the stressing of multi-rib thin wings of low aspect ratio and rectangular planform, Aero. Res. Counc. Lond. Rep. Mem. 3052, 45 pp., 1958.

Exact equations of elasticity are derived for a two-spar multi-rib wing of rectangular cross section and rectangular planform. Numerical examples are presented for a thin wing of low aspect ratio and the results obtained are compared with those obtained by con-

ventional methods. Three loading conditions are considered: (1) symmetrical about the spanwise center line; (2) antisymmetrical about the spanwise center line; and (3) loading along only one spar.

Comparisons made in the numerical examples indicate that for the symmetrical loading condition the conventional methods of analysis provide satisfactory results except for the chordwise stresses in the skin and the cross-sectional distortion of the ribs. However, for antisymmetrical loadings, conventional methods yield optimistic results. W. K. Rey, USA

3287. Freeston, W. D., and Suppiger, E. W., A note on Mohr's stress circles, *J. Franklin Inst.* **268**, 2, 106–110, Aug. 1959.

This article presents a brief discussion of the use of Mohr's stress circles for the solution of the general three-dimensional state of stress problem. The state of stress at a point on a surface of a sphere is defined in terms of the generalized coordinates θ and ϕ, the angles defining the direction of the normal to the surface at that point. Expressions for the normal and shearing stresses at the point on the surface are developed in terms of θ and ϕ. The application of Mohr's stress circle to the graphical solution of these expressions is discussed. The article is an extension of AMR **4**(1951), Rev. 2470.

N. Khachaturian, USA

3288. Lyubimov, V. M., Elastic equilibrium of a circular ring sector (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 137–141, Mar. 1958.

Author shows how to find the "basic" tensor of stress in a circular ring sector, loaded symmetrically to its two planes of symmetry by distributed loads, acting either normally or tangentially to its faces. The paper is based on an approximate method developed by Filomenko-Borodich ["Some generalizations of Lamé's problem for an elastic parallelepiped" (in Russian) *Prikl. Mat. Mekh.* **17**, no. 4, 1953; AMR **6**(1954), Rev. 3149] using Castigliano's variational principle. According to Filomenko-Borodich the tensor of stress in each point of an elastic parallelepiped, loaded on all faces, can be found as the sum of a "basic" and a "correcting" tensor.

A. Werfel, Israel

3289. Sakadi, Z., Boundary value problem for an elastic body with a plane crack, *Mem. Fac. Engng., Univ. Nagoya* **10**, 2, 191–196, Nov. 1958.

The analysis of stresses in an infinite elastic solid with arbitrary shape of plane crack by the method of Fourier transforms is shown. Stresses for the case of a crack of elliptic shape are given in explicit forms. T. H. Lin, USA

3290. Wegner, U., Contribution to the stability criteria of the theory of elasticity (in German), *Ing.-Arch.* **28**, 357–359, Mar. 1959.

3291. Sternberg, E., and Chakravorty, J. G., On inertia effects in a transient thermoelastic problem, *ASME Trans.* **81** E (*J. Appl. Mech.*), 4, 503–509, Dec. 1959.

Authors develop dynamic solution for transient thermoelastic problem of semispace constrained against transverse displacements and subjected to uniform time-dependent heat flux on entire boundary. Closed-form displacement functions are obtained for a stepwise (sudden) increase in surface temperature, the stress solution for which was previously obtained by Danilovskaya. A new closed-form solution is derived for a ramp-type (linear increase) time-dependent temperature function. The quasi-static solution ignoring inertia effects is shown to approach smoothly the asymptotic values represented by steady-state conditions. In contrast, dynamic solutions exhibit discontinuous slopes in the stress distributions, corresponding to presence of shock fronts propagating as elastic waves in the medium. The ramp-type temperature input is shown to result in far lower transient stresses than the physically unrealistic case of instantaneous temperature change considered previously. N. A. Weil, USA

3292. Nowacki, W., Transient thermal stresses in viscoelastic bodies (in English), *Arch. Mech. Stos.* **11**, 5, 649–669, 1959.

Maysel's method for solving problems of thermal stresses in perfectly elastic bodies is extended to the case of viscoelastic ones. Theoretical considerations result in establishing a two-stage method for treating dynamical problems belonging to time-dependent temperature fields in viscoelastic media. The first step consists in solving the quasi-statical problem; the second stage takes into account the influence of inertia forces.

The present article forms the first part of the paper. It gives general outlines of the method and considers in detail quasi-statical problems. As examples are solved the case of plane, cylindrical and spherical symmetry of the basic temperature distribution.

Apart from the physical and technical significance, the reading of the paper is a real intellectual enjoyment for everyone having adequate mathematical equipment.

V. Vodicka, Czechoslovakia

3293. Saito, H., Stress of circular disks with circular openings, subjected to shear, *Technol. Rep. Tohoku Univ.* **21**, 1, 93–106, 1956.

Author analyzes the stress concentration at internal holes of a disk loaded by uniform circumferential shear reacted by a concentrated torque at the center. The internal holes are located uniformly about a concentric circle. The complex variable method is used, the stress potentials being expanded in power series of the appropriate variables. The boundary conditions are satisfied by a perturbation method, which apparently converges satisfactorily if the holes are not too close. Experimental checks are obtained by strain gages and brittle lacquer. J. M. Frankland, USA

3294. Ignaczak, J., Direct determination of stresses from the stress equations of motion in elasticity (in English), *Arch. Mech. Stos.* **11**, 5, 671–678, 1959.

This important paper derives first the general equations of motion of the theory of elasticity in terms of time-dependent stresses. The first application of the theory is the complete solution for an infinite medium under the action of arbitrary time-dependent forces. The next example relates to an instantaneous nucleus of thermoelastic strain appearing as one of the simplest particular cases of the author's general conception.

Paper concludes with establishing the generalized equations of motion of thermoelasticity in terms of stresses for the case of dynamical problems. Author presents also the related Green's function for an infinite region. V. Vodicka, Czechoslovakia

3295. Yamamoto, M., Torsion of an incomplete composite beam (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **63**, 17–22, July 1959.

Author proposes a new theory of torsion of an incomplete composite rectangular beam composed of two rectangular beams of different shear modulus combined at their sides, on the basis of Saint-Venant's torsional theory, and examines the torsional moment and the stress distribution in the bond surface by means of numerical calculations. From author's summary

Courtesy of the Editorial Committee,
Japan Society of Civil Engineers

3296. Zapalowicz, W., Torsion of prismatic bars of regular polygonal cross section (in English), *Arch. Mech. Stos.* **11**, 5, 559–590, 1959.

This is a welcome contribution to surmounting the well-known difficulties arising in torsional calculations of polygonal shafts with more than three or four sides, where the absence of rigorous methods leads to using different approximate formulas with un-

known degree of approximation. Using conformal mapping of the polygon of n sides on a unit circle, author derives a general solution of the torsional problem for polygonal bars having an arbitrary number of sides. The results follow in form of infinite series, giving the possibility of deriving approximate formulas with any prescribed degree of accuracy.

V. Vodicka, Czechoslovakia

3297. Csonka, P., Torsion of a square-shaped tube clamped at both ends (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24**, 3/4, 379–390, 1959.

Paper deals with the torsional problem of a square-formed tube, the walls of which are of constant thickness. The tube is clamped at both ends. Usual assumptions of the theory of disks, or slabs, respectively, are applied. In contradiction with the known theory on tubes with thin walls considering only membrane-forces in the tube-walls, present paper also allows for the bending and torsional resistances of the lateral walls. That is why the deduced formulas are more accurate than the known formulas referring to thin-walled tubes.

The paper is completed by a numerical example. This draws a parallel between the interior forces and angular displacements computed on the basis of the published, more accurate method, and the values resulting from the approximate theory relative to tubes with thin walls. From this comparison it appears that roughly identical values result for normal forces acting on the cross sections in compliance with both theories. On the other hand, the normal forces acting on the length sections differ from each other in a considerable degree, which means that the torsional stiffness of the tube is somewhat larger than the value given by the approximate theory.

From author's summary

3298. Chattarji, P. P., Stress concentrations around a small inclusion on the axis of a circular cylinder under torsion, *Indian J. Theor. Phys.* **6**, 2, 51–64, June 1958.

The presence of inclusions in a body under any kind of stresses produces a considerable weakness in it. Author gives the stress equations for the special case of a small rigid inclusion on the axis of a circular cylinder under torsion. The studied flaws are: (a) two spheres not touching each other; (b) two spheres touching each other; (c) inverse of an ellipsoid with respect to its center.

The problem is solved exactly from the differential equation for the angle of rotation of an elemental ring in a cross section of the cylinder. Legendre and Bessel functions are involved in the final equations. The angle of rotation is obtained as convergent series in cases (a) and (c), and as an integral in case (b). Numerical values are given for the solution in case (a).

G. O. Fritz, Mexico

3299. An, B., Elasticity problem of a rigid sphere pressed against the plane surface of a semi-infinite elastic solid (The effect of friction on the contact surface), *Bull. JSME* **2**, 6, 244–251, May 1959.

Values of the stresses and displacements for the title problem are obtained by using Hankel's transform. Approximate solutions are also obtained for the influence of friction on the contact surface. There are two obvious misprints: E in equation [7] should be replaced by G and the term $(C' + D'z)^{-\xi z}$ in equation [11] by $(C' + D'z)e^{-\xi z}$.

D. N. Mitra, India

Viscoelasticity

(See also Revs. 3292, 3428)

3300. Busse, W. F., and Starr, F. C., Change of a viscoelastic sphere to a torus by random impacts, *Amer. J. Phys.* **28**, 1, 19–23, Jan. 1960.

When a small (<2.5g) ball of silicone putty was put into a vibrating cylinder, it first bounced around like a rubber ball. After some time the motion produced by the random impacts caused the sphere to change to a torus, and ultimately it broke up into smaller "dog-bone"-shaped pieces. If the size of the initial sphere was increased to 4-5 g or more, the spherical shape remained stable for many hours. When the initial shape was changed from a sphere to a cube to a prism, the minimum critical size that would form a stable sphere increased from about 3 to 6 to 20g, respectively. The formation of the torus is due to the combined effect of the spectrum of relaxation times of the material, the short time of impacts with the wall, and the tendency of a body in free flight to rotate around the axis having the highest moment of inertia.

From authors' summary by J. Rinehart, USA

3301. Thurston, G. B., Theory of oscillation of a viscoelastic medium between parallel planes, *J. Appl. Phys.* **30**, 12, 1855–1860, Dec. 1959.

The general equation of motion is set up for the problem and geometry defined by title. Solutions are developed for motion parallel to the boundary planes and sinusoidal in time. Examples of velocity profiles are shown graphically, in considerable detail, and functions related to acoustic resistance and reactance are plotted. Author finally discusses possible application of results to flow in rectangular tubes, and suggests that this may indicate an experimental method for measuring viscoelastic properties of fluids.

F. C. Roesler, England

3302. Lee, E. H., and Radok, J. R. M., The contact problem for viscoelastic bodies, Brown Univ., Div. Appl. Math., TR 47 (Contract Nonr-562(10) (NR-064-406), 31 pp., Jan. 1959.

The contact problem in viscoelasticity is one in which different types of boundary conditions are prescribed depending on whether boundary points inside or outside the region of contact are considered. Since, in general, the contact region varies with time, this leads to a problem which cannot be treated directly by application of the Laplace transform, which has formed the basis for most published viscoelastic stress distribution solutions. It is shown that the solution of the viscoelastic counterpart of the Hertz problem in elasticity can be deduced from the elastic solution by the method of functional equations. A particular example is presented, and the marked effect of viscoelastic behavior on the pressure distribution in the contact region is illustrated. The problem also illustrates the tentative nature of this method of approach and the need for a separate confirmation of the solution.

The solution is presented for general linear viscoelastic operators, and offers the possibility of determining these from a contact test. The relation of the present theory to earlier work is discussed.

From authors' summary by W. H. Hoppmann, II, USA

3303. Levi, F., Instability behaviour in a hyperstatic field under yield elastic conditions of restraint (in Italian), *Ric. Scient.* **29**, 7, 1452–1464, July 1959.

This is an attempt to picture creep behavior of slightly initially curved concrete columns in compression in an elementary way, considering relaxation of constraining end moments from linear viscous action of column. Integration is performed approximately, retaining only first term of Fourier expansion, the coefficient of which is a function of time to be determined. Experiments with a rectangular frame of plexiglass are reported and said to confirm conclusions of theory with respect to creep behavior during 48 hours.

F. K. G. Odqvist, Sweden

3304. Kennedy, C. R., Harms, W. O., and Douglas, D. A., Multiaxial creep studies on Inconel at 1500 F, *Trans. ASME* **81D** (*J. Basic Engng.*), 4, 599–609, Dec. 1959.

3305. Mordfin, L., Halsey, N., and Greene, G. E., Investigations of creep behavior of structural joints under cyclic loads and temperatures, NASA TN D-181, 37 pp., Oct. 1959.

Eighty-two structural joint specimens were tested to evaluate the effects of cyclic loads and cyclic temperatures on creep and rupture. The specimens included riveted joints of 2024-T3 clad aluminum alloy, and riveted and spot-welded joints of 17-7 PH (TH 1050) stainless steel. The results of these tests show a wide variance but indicate certain trends which permit the estimation of the cyclic creep behavior of joints.

An analysis of the effects of stress concentration on the tensile rupture strength of riveted joints is presented in an appendix. This, together with data from several other laboratories, shows that the effects are small for joints fabricated from notch ductile materials and conventional rivets.

From authors' summary

3306. Johnson, A. E., Henderson, J., and Mathur, V. D., Complex stress creep relaxation of metallic alloys at elevated temperatures, Parts I, II, *Aircr. Engng.* **31**, 361, 75–79, Mar. 1959; **31**, 362, 113–118, Apr. 1959.

The nature of the relation between complex stress creep under conditions of relaxation and complex stress creep under conditions of steady stress was investigated. The required relation has been examined for an RR59 aluminum alloy at 200 C and for a magnesium (2% aluminum) alloy at 50 C. For RR59 aluminum alloy at 200 C and for magnesium (2% aluminum) alloy at 50 C, a reasonably close prediction of the course of relaxation complex stress time curves is given by the mechanical age-hardening theory of creep on the basis of steady complex stress creep data.

Other mechanical theories tend to predict for a specific relaxed stress a relaxation time in excess of that noted in experiment.

From authors' summary

3307. Johnson, K. L., The influence of elastic deformation upon the motion of a ball rolling between two surfaces, Instn. Mech. Engrs., Prepr., 14 pp., 1959.

Tangential contact force and relative angular velocity of spin at point of contact give rise to tangential frictional tractions which are shown to result in velocity creep of ball perpendicular to rolling path. Creep velocity depends on magnitudes of tangential force and velocity of spin. Creep measurements have been made over a wide range of conditions of rolling and results are reduced to nondimensional form in terms of effect of tangential forces and spin. The resistance to rolling has been measured and detailed mechanism of the rolling process is discussed.

G. G. Meyerhof, Canada

Plasticity

(See also Revs. 3300, 3340, 3356, 3357, 3359, 3363, 3384, 3393, 3614)

3308. Yamaguchi, H., A theory on the velocity field in the plastic flow of granular materials (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **63**, 8–16, July 1959.

In the present paper, general theory of the velocity field in the plastic flow of granular materials with frictional resistance has been discussed. An extension of Geiringer's equation and compressibility law in the flow state are obtained by making characteristic lines of velocity coincide with those of stress. By using the concept of plastic potential, relations between stress and strain increment in two- and three-dimensional stresses, and the yield condition are derived. The former relations are found to be the same as Levy-Mises ones. In cases where the angle of internal friction is not large, the above yield condition and newly introduced Poisson's ratio are shown to agree fairly well with the corresponding expressions already given by Prof. Hoshino. Dilatancy formulas in the shearing flow are derived from the present theory, and proved valid experimentally.

From author's summary
Courtesy of the Editorial Committee,
Japan Society of Civil Engineers

3309. Voloshenko-Klimovitskii, Yu. Ya., On the possibility of separate estimates of strength and plasticity of metals in testing impact viscosity (in Russian) *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 42–46, June 1958.

Authors attempt to separate out contributions of strength and plasticity to impact energy by measuring the shape, amplitude and length of the stress impulse before fracture. A standard tensile impact test is used and the shape of the stress pulse is plotted on an oscillograph using a dynamometer. Fracture times are 20–30 microseconds. Since deformation requires 50–500 microseconds, the length of the pulse can be used as a measure of ductility. The energy is related to the product of amplitude and duration and the amplitude to the yield or tensile strength.

R. W. Guard, USA

3310. Zhukovskii, V. S., On the coefficient of strengthening and the character of propagation of plastic zones in notched bars (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 116–120, May 1958.

Author reviews the different solutions for the stress distribution in a notched bar for plane strain, plane stress and for different notch geometries. The growth of the plastic zone is calculated from the different solutions. Solutions are compared to experimental results on four different geometries in 0.45C steel bars. Author concludes that limit for case of plane strain is described by Hill's formula [*J. Mech. Phys. Solids* **1**, p. 19]. For thin bars the value of strengthening coefficient is less than Hill's formula predicts because condition of plane strain does not exist.

R. W. Guard, USA

3311. Save, M., Remarks about plane strain and plane stress problems (in French), *Bull. Centre Etudes Genie Civ.* **9**, 63–84, 1957.

See AMR **13** (1960), Rev. 583.

3312. Colonnetti, G., New points of view of three-dimensional elastic-plastic equilibrium, Parts 1 and 2 (in Italian), *Atti Accad. Naz. Lincei, R. C. Cl. Sci. Fis. Mat. Nat.* **25**, 3/4, 140–145, Sept./Oct. 1958; **25**, 5, 239–245, Nov. 1958.

Rods, Beams and Strings

(See also Revs. 3229, 3288, 3295, 3310, 3335, 3345, 3382, 3397, 3401, 3406, 3419)

3313. Genensky, S. M., and Rivlin, R. S., Infinitesimal plane strain in a network of elastic cords (in English), *Arch. Rational Mech. Anal.* **4**, 1, 30–44, Nov. 1959.

The problem of plane deformation of a sheet of fabric is considered. The cords are perfectly flexible and extensible elastic, and cannot move relative to each other at their points of intersection.

In part I, equations of equilibrium and expressions for the edge tractions are obtained. In part II, equations are simplified for the case when the displacement gradients are small compared with unity. It is shown how the displacements throughout the sheet may be obtained when: the edge displacements are specified, the edge tractions are specified, or in the mixed case.

N. E. Cristescu, Roumania

3314. Green, A. E., The equilibrium of rods (in English), *Arch. Rational Mech. Anal.* **3**, 5, 417-421, Sept. 1959.

Paper presents a rigorous deduction of the equilibrium equations for rods, expressed in terms of stress resultants and couples, from the general equations of three-dimensional equilibrium in curvilinear coordinates. Suggestions are also made for the development of a complete theory of rods. W. S. Hemp, England

3315. Mrazik, A., Analysis of beams of composite cross-section. Parts 1 and 2 (in Czech), *Stavebnicky Casopis* **6**, 2, 65-82, 1958; **6**, 3, 138-145, 1958.

3316. Raymondi, C., On the problem of beams with continuous elastic support (in Italian), Atti Ist. Sci. Costr., Univ. Pisa Publ. no. 57, 9 pp., 1958.

The classical theory of the elastic supported beam developed by H. Zimmermann does not consider the mutual influence of the supports, while Wieghardt introduces a nucleus influence function which permits to take into account this action for a continuous loading of the beam. Author extends this method by concentrated loads and couples, and by application of the theorem of Maxwell and by partial integration of the double functions obtains a closed solution for bending moments and deformations of the elastic supported beam. Author gives the trivial example of a beam elastically supported on another beam of different rigidity, thus demonstrating the application of his method. This is a valuable amplification of the theory of Wieghardt. H. Beer, Austria

3317. Raymondi, C., Contribution to the study of a beam on elastic foundation (in Italian), Atti Ist. Sci. Costr., Univ. Pisa Publ. no. 60, 11 pp., 1958.

This paper deals with a special application of author's theory of the elastically supported beam under concentrated loads and couples. The considered beam contacts the elastic isotropic semispace. The problem is solved by separating the nucleus influence function in the characteristic integral, maintaining the validity of the linear differential equation of the beam and formulating some general properties of the foundation. The final solution is given by a regular integral equation of Fredholm. Some aspects of approximate solutions trace back to the fundamental differential equation of Wieghardt. H. Beer, Austria

3318. Chang, F. S. C., Theory of cohesive peeling of adhesive joints, *J. Appl. Phys.* **30**, 11, 1839-1841 (Letters to the editor), Nov. 1959.

Author combines equations for theories of beam on elastic foundation and for a three-element spring and dashpot model to obtain solution for cohesive peel strength of a stringy adhesive joint subjected to a 90 degree peeling force. Steady infinite peeling speed yields simple limiting case for a Hookean adhesive. Remaining terms in infinite series solution account for retardation effect according to peeling speed used. Author disproves assumption often erroneously made that bent adherend takes the shape of segment of circle. Shape is determined instead by thicknesses and moduli of adhesive and adherend. Corroborative experimental data will be published at a later date. S. Yurenka, USA

3319. Leinss, H., Deflection of heavily loaded and one-end-clamped springs (in German), *Ing.-Arch.* **28**, 173-177, Mar. 1959.

If bending deflection becomes large, there are two additional influences acting one against another, causing difference from results of usual linear theory, though material remains stressed elastically. Perpendicular distance from force acting is diminished, and exact expression for curvature now depends on slope of deflection curve. Therefore relation between load and deflection becomes nonlinear, e.g. if stiffness would increase. If deflection is not too much (e.g. 0.3 of the spring length), correcting terms may be taken from usual linear theory and series developments stopped after a few members. Finally, deflection is determined by an equation of second degree, while a simplification of it gives better agreement with experimental data than the more exact solution. W. Mudrak, Austria

3320. Carnegie, W., Experimental determination of the centre-of-flexure and centre-of-torsion coordinates of an asymmetrical aerofoil cross-section, *J. Mech. Engng. Sci.* **1**, 3, 241-249, Dec. 1959.

Paper describes technique for measuring accurately the centers of twist and bending of uniform cantilever beam with airfoil cross section. G. W. Housner, USA

Plates, Shells and Membranes

(See also Revs. 3285, 3338, 3340, 3341, 3342, 3346, 3354, 3357, 3358, 3359)

Book—3321. Kovalenko, A. D., Circular plates of variable thickness [Kruglie plastini peremennoi tolshini], Moscow, State Publishing House for Physico-Mathematical Literature, 1959, 294 pp. 11.10 rubles.

This represents the first book devoted entirely to the problem of small deformations of elastic circular plates of variable thickness. In all cases the plates are axisymmetric with regard to the thickness variation, but nonaxisymmetric loadings are considered.

The first chapter develops the differential equations of bending of thin circular plates of variable thickness. The general case of nonaxisymmetric bending is treated, but no account is taken of membrane effects. Governing equations for symmetric deformations of variable thickness circular plates with small initial deformations are also developed. Lastly, equations are developed for the symmetric deformations of variable thickness plates subjected to nonuniform heating.

Symmetric bending of variable thickness plates is the subject of the second chapter. Thickness variations considered are (a) that in which the flexural rigidity varies as the radial coordinate to a given power, which leads to the hypergeometric equations, (b) that in which the flexural rigidity varies as the product of the absolute value of the radial coordinate to a given power and the absolute value of this coordinate subtracted from unity, this last quantity being raised to another power. This leads to the same type of governing equation. Also considered are (c) exponential variations of thickness and (d) linear variations of thickness. The bending of plates of linearly varying thickness supported on an elastic foundation and the axisymmetric vibrations of plates of linearly varying thickness conclude the chapter. Loadings considered for these cases include (a) centrally located concentrated forces, and (b) uniformly distributed normal loads.

The third chapter is concerned with antisymmetric bending of circular plates. Various cases involving linear and exponential variations of thickness are considered (all axisymmetric), the plates being subject to normal loadings that vary in a harmonic fashion around the plate. Most of these cases again lead to the hypergeometric equation. The antisymmetric free vibrations of plates with linearly varying thickness are considered in detail.

Chapter four deals with so-called cyclic symmetric bending of circular plates. This implies loadings which are distributed among a number of uniformly spaced radial lines. Thickness variations treated include the linear variation as well as variations such that the flexural rigidity varies as some power of the radial coordinate. The loading is restricted to uniformly distributed normal pressure. The fifth and last chapter is concerned with complex problems in the symmetric bending of plates and includes such topics as (a) deformations of annular plates with a slight initial curvature subject to normal load, (b) initially curved plates rotating about their geometric axes, and (c) linearly varying thickness plates in which

the modulus of elasticity of the material varies with regard to the plate thickness.

Much of the work in this volume is original with the author. Certain cases presented refer to the original works of Conway, Olsson, and others. The book is a very comprehensive presentation of existing information in this specialized area and is well referenced. W. A. Nash, USA

3322. Gerisch, W., On the problem of an elastic rigidly clamped plate (in German), *Arch. Rational Mech. Anal.* **2**, 3, 227–242, Dec. 1958.

Two systems of orthonormal functions are considered: one composed of particular solutions of Darboux differential equation, used in unorthonormalized state by Filonenko-Boroditch, and another formed by associated spherical functions which, in unnormalized state, represent associated Legendre polynomials. It is proved that both systems are complete with respect to Hilbert space L^2. As a numerical example the problem of free vibration of a rectangular plate (2:1) rigidly clamped and acted on by a uniform shearing stress at the edges is solved using the second system of functions. The results show good agreement with the results obtained by other authors. J. Nowinski, USA

3323. Kawai, T., On the bending of a sectorial plate (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **18**, 63–80, 1958.

The plate is simply supported along the radial edges and clamped along the circular arc boundary. A unit concentrated transverse load is applied at an arbitrary point, and the resulting deflection surface is determined using classical plate theory. Two infinite series representations of the deflection surface, which is the Green's function for the boundary-value problem, are given. One is a Fourier-Bessel double series; the other is a single series valid for any sector other than a semicircle. The latter is analogous to the Clebsch solution for a complete circular plate.

The limiting case of an infinite wedge plate is obtained by letting the sector radius become infinite. The resulting solution is expressed in closed form and is also derived directly by conformal mapping techniques. The dependence on the sector angle of the possible stress concentration or singularity at the point of the wedge is discussed, and contour maps of the moment influence surfaces are drawn for a 60° wedge plate with a concentrated load on the axis of symmetry and zero Poisson ratio.

R. A. Clark, USA

Book—3324. Lur'e, A. I., Statics of thin-walled elastic shells, (United States Atomic Energy Commission, Translation series AEC TR-3798), Washington, D. C., Office of Technical Services, Department of Commerce, 1959, 210 pp. $2.

Originally published in Russian in 1947, this translation into English now makes this book readily available. The quality of the translation appears to be excellent.

The book is divided into four chapters: (1) Equilibrium equations of an elastic, symmetrically loaded shell of revolution; (2) Solution of the fundamental differential equations for shells of the simplest geometric shapes, including cylindrical, conical and spherical shells; (3) Approximate solution of the fundamental differential equations of a symmetrically loaded shell of revolution, dealing mainly with stresses arising at the junctures of various shaped shells with end closure plates; and (4) Arbitrarily loaded cylindrical shells, treated by the methods of Fourier series as well as complex stress functions.

The original title of the book was: "Statika Tonkostennykh Uprugikh Obolochek," published by Gos. Izdat. Tekh.-Teor. Lit., Moscow, 1957, 252 pp. W. A. Nash, USA

3325. Reissner, E., On the solution of a class of problems in membrane theory of thin shells, *J. Mech. Phys. Solids* **7**, 4, 242–246, Oct. 1959.

The membrane stresses in surfaces of revolution $r = f(z)$, where r is the radius of the parallel and z the axis of symmetry, are determined by means of suitable stress functions when the normal stresses are of the form $f(z) \cos \theta$ and the shear stresses of the form $f(z) \sin \theta$. The results are used to derive the membrane stresses in cantilevered shells under lateral end loads and moments, and under hydrostatic loads. The particular case of an ellipsoidal shell under hydrostatic load is solved in detail in order to enable the comparison with an earlier solution of the same problem. M. G. Salvadori, USA

3326. McIlroy, M. D., Linear deformations of conical shells, *J. Aero/Space Sci.* **26**, 4, 253–254 (Readers' Forum), Apr. 1959.

In this short note two relevant differential equations of fourth order for the stress function and the transverse displacement are transformed into a set of independent fourth-order ordinary differential equations of generalized hypergeometric type by introducing a new complex function. This basic equation is solved using "cone" functions, the formulas for some of which are given.

Details of the work are contained in a doctoral thesis presented at Mass. Inst. Tech. 1958. Reviewer hopes that the detailed work will also appear in print. M. Hampl, Czechoslovakia

3327. Mesmer, G., In connection with a group of singularities for spherical shells under membrane stresses (in German), *Ing.-Arch.* **28**, 208–212, March 1959.

The rectangular coordinates with their origin coinciding with the center of a spherical shell cut the shell in six poles. If at each pole a concentrated force and moment vector is acting, such that the system is in equilibrium, the resultant membrane state can be obtained as a superposition of 36 elementary loading cases. Due to symmetry only six different elementary cases are actually needed for the determination of the resulting membrane stresses.

The membrane state solution for an unloaded spherical shell can be given in terms of elementary functions containing four arbitrary constants, as earlier known. Author discusses the singularities of that solution and obtains the six elementary cases by choosing different values of the arbitrary constants and the number of waves. Two more cases are obtained in that way but author shows that they may be constructed from the other six. Resulting stress field is presented graphically for all eight cases in a figure, giving a clear picture of corresponding membrane states.

F. I. Niordson, Denmark

3328. Withum, D., Circular cylindrical shells with circular cutouts under the influence of shear stresses (in German), *Ing.-Arch.* **26**, 435–446, Dec. 1958.

Author treats the problem of a thin closed circular elastic shell under torsion which is weakened by circular cutout. It is assumed that cylinder is long enough so that cutout does not modify conditions at terminal sections. Basic differential shell equation used is due to Zerna, which is a fourth-order linear equation for a complex function, the real part of which is transverse normal deflection of shell middle surface and the imaginary part in Airy stress function. Using Fourier methods problem is reduced to solution of a series of coupled ordinary differential equations which is carried out by perturbation method. Convergence is satisfactory. Numerical results are given which show that stress concentration is larger than in corresponding two-dimensional plate problem with circular hole. Z. Hashin, USA

3329. Raetz, R. V., and Pulos, J. G., A procedure for computing stresses in a conical shell near ring stiffeners or reinforced intersections, David W. Taylor Mod. Basin Rep. 1015, 33 pp., Apr. 1958.

Authors develop an approximation to more complete theory of stress for a conical shell of title problem. The approximation proves to differ little from more exact theory of Meissner-Dubois,

but offers advantage of more rapid calculation. An example of a cone-cylinder intersection is demonstrated numerically. Suggestion for extending approximation to other geometries is given.

The report may be of interest to those design engineers who need quick answers. A. P. Boresi, USA

3330. Palii, O. M., Stability of circular cylindrical shells clamped along curvilinear edges (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 126–128, Jan. 1958.

Author refers to a formula derived by W. A. Nash in the *J. Aero. Sci.* **21**, no. 5, May 1954 [AMR **8** (1955), Rev. 67], where it is shown that clamping of edges in a cylindrical shell increases the stability by 30–40% as compared to a shell freely supported. Nash's conclusion is a result of the assumption that the loss of stability is of the form

$$[1 - \cos (2\pi x/L)] \sin n\theta$$

which does not reflect the character of the stressed shell. The clamping does affect the change in stress of the shell only in the neighborhood at the edges, but there is no reason to expect a significant increase of the critical pressure, either in long shells or shells of medium length.

Author uses the energy method and obtains a general solution both for long and medium long shells. The theory is based on the assumption that the loss of stability can be obtained by superimposing on the deflection of the freely supported shell due to uniform pressure, the deflection due to end moments $\kappa M = m \sin \theta$, where M is obtained from the condition that $\mathrm{div}/\partial\xi = 0$ when $\xi = 0$. Author plots his solution as a function of p_{crit} and the ratio l/r and compares his values with that of Nash's, showing that Nash overestimated the increase in critical pressure by 30–40%.

From author's summary by M. Maletz, USA

3331. Yamanaka, H., and Ono, K., On the strength of the cross stay reinforcing the outer firebox of a locomotive-type boiler, *Bull. JSME* **2**, 7, 446–451, Aug. 1959.

The dimensioning of equipment of the type referred to in the article is done mostly "by tradition," i.e. by using "time-honored" dimensions and designs. Therefore the critical and theoretically correct approach of the authors of the article under review should be welcomed.

The rigorous derivation of formulas is followed by the simplification, each of which is properly explained and justified. The experimental checking of computed conditions resulted in a confirmation of the simplified formulas developed by the authors.

The article will be of considerable value not only to designers of locomotive-type boilers, but to all those who are concerned with the design of fabricated vessels and structures experiencing substantial strain and distortion under load.

A. B. Zeitlin, USA

Book—3332. Aleksandrova, A. Ya., editor, Problems in the analysis of elements of aviation construction [Vopros' Rascheta Elementov Avitsionnikh Konstruktsii], Moscow, State Publishing House of the Defense Industry, 1959, 168 pp. 10.60 rubles

This volume contains nine original papers, each dealing with some aspect of the elasticity of three-layered sandwich-type panels and shells. The first paper, "Tests of the strength of three-layered panels with cores of foam plastic" by A. Ya. Aleksandrov and L. E. Bryukker, contains results of longitudinal compression tests on rectangular aluminum face sandwich panels having either isotropic or orthotropic foam plastic cores. Tests results are shown to be in fair although not completely satisfactory agreement with an unavailable 1958 dissertation. Results of an analogous investigation concerning compression of cylindrically curved panels are also presented. The paper concludes with results of fatigue tests for flat sandwich panels subject to pure bending. This paper appears to offer little that is not available in Western literature for tests on equivalent materials. The second paper, "Analysis of cores of sandwich plates with a consideration of tearing" by A. Ya. Aleksandrov, employs linear theory to investigate the stresses in sandwich plates having either a slight initial curvature or a periodic wave-form present in the facings. Stresses due to bonding, as well as the effect of breaking of the bond in certain regions, are given. A complete understanding of the paper would be based upon a knowledge of an unavailable 1948 dissertation. The third paper, "Large deflections of three-layered cylindrical shells" by L. M. Kurshin, applies variational methods to derive equilibrium equations of such structures and then investigates in detail the compression of a cylindrical panel. Results are shown to be in agreement with the known theory of Wang and Rao [AMR **5** (1952), Rev. 2802].

The fourth paper, "Stability of compressed three-layered simply supported cylindrical panels and cylinders with corrugated cores" by L. M. Kurshin, applies nonlinear theory to the title problem to formulate the equilibrium equations in terms of displacements. These equations are then solved for the case of an axially compressed cylindrically curved panel with corrugated core, which is treated as an orthotropic material. Load-deflection plots are given for a wide range of geometries. No references or comparisons are given to several recent American papers on this same topic. The fifth paper, by the same author, "Stability of compressed three-layered curved cylindrical panel with clamped ends and longitudinal expansion permitted," treats the title problem in a routine fashion by small-deflection theory and presents eigenvalues in graphical form. The sixth paper, again by the same author, "Calculation of the bending rigidity of a cylindrically curved three-layer panel subject to longitudinal compression," employs linear shell theory to investigate the title problem.

The seventh and eighth papers, "Torsion of open cylindrical shells with ring reinforcement" and "Torsion and bending of circular cylindrical shells, reinforced by elastic rings" by S. I. Galkin, present analyses of these problems based solely upon membrane action in the shell with no consideration of bending action. Significant stresses are presented in graphical form for a wide range of parameters. The last paper, "Analysis of nonsteady temperatures in I-beam elements" by N. I. Nazarov, M. S. Povarnitsin, and E. V. Yurlova, investigates the title problem by a common balancing procedure as well as by direct integration of the governing equations. Results are compared with those obtained by Pohle and Oliver [AMR **7** (1954), Rev. 1638].

W. A. Nash, USA

3333. Cremer, L., and Heckl, M., Additions to the theory of floating floors (in German), *Acustica* **9**, 1, 200–210, 1959.

The simple theory of the floating floor considers no side boundaries and neglects the possibility of lateral coupling by the elastic interlayer. The theory is improved by introducing the propagation of cylindrical waves in this layer. This concept results in a change of the "stiffness" of the interlayer which can be observed in practice. Only when the finite size and the boundary conditions of the ceiling and the boundary conditions of the floating floor—which are different from those of the ceiling—are considered can the deviations of the experimental results from the simple theory be explained. From authors' summary

Buckling

(See also Revs. 3290, 3303)

Book—3334. Naleszkiewicz, J., Problems of elastic stability [Zagadnienia statecznosci sprezystej], Warszawa, Panstwowe Wydawnictwo Naukowe, 1958, 470 pp.

This monograph on the problems of stability of elastic systems also contains the foundations of the theory of elastic-plastic

buckling. Most attention is devoted to bars and beams, although considerable space is devoted to the stability problems of plates.

At the beginning the notion of stability is discussed on the basis of the so-called elastic pendulum and the mathematical foundations of the problem of simultaneous bending, compression and torsion of bars and beams.

Flexural and torsional buckling and buckling of slender bars with various loads constitute the subjects of the next chapters. Besides these classical problems the author discusses more recent problems such as the stability of thin-walled bars, with the foundations of the general theory of structures of this type, and the buckling of rectangular plates, the case of stiffening by an orthogonal rib network being also discussed. A separate chapter is devoted to the less-known problem of strength of elastic systems beyond the stability limit, aircraft structures being given special consideration.

Variational, chiefly energy, methods are used in general. These methods as well as other approximate solutions are discussed on some 50 pages.

Compared with numerous foreign monographs this book is distinguished for the discussion of many most recent, principally Polish, scientific achievements. The present edition is superior to the first one from the point of view of variety of problems discussed and also from the editorial point of view.

Numerous tables, diagrams and monographs make this book useful for readers with less advanced mathematical background.

M. Sokolowski, Poland

3335. Hansell, W., and Winter, G., Lateral stability of reinforced concrete beams, *J. Amer. Concr. Inst.* **31**, 3, 193–213, Sept. 1959.

Some concrete design specifications, including the ACI Code, in various ways limit the distance between lateral supports of beams, presumably to safeguard against lateral buckling. The present investigation is intended to furnish some factual information on which to base such provisions. Ten tests on deep narrow beams have been carried out with unbraced lengths ranging from 28.8 to 86.4 times the beam width. No reduction in strength was observed over this range, showing the absence of lateral buckling. A tentative theory of lateral instability of reinforced-concrete beams, including the effects of inelasticity and cracking, is given. It agrees with the tests in showing that present Code provisions are too restrictive, particularly for ordinary steel strengths. Theory indicates that closer lateral supports are required for high strength reinforced beams than for ordinary strength reinforcement.

From authors' summary by K. Angervo, Finland

3336. Hoff, N. J., The idealized column (in English), *Ing.-Arch.* **28**, 89–98, Mar. 1959.

This paper is an interesting review of buckling theory as applied to an idealized I-section column. Formulas for the reduced and tangent modulus buckling loads are developed and a clever graphical method is described. A creep buckling analysis is given, with particular reference to the case where secondary creep alone is significant.

L. Mordfin, USA

3337. Hollan, I., Stability of slender reinforced concrete columns (in Czech.), *Stavebnicky Casopis* **6**, 4, 244–256, 1958.

3338. Bisplinghoff, R. L., Finite deflections of thin cambered elastic plates, *J. Franklin Inst.* **268**, 4, 270–277, Oct. 1959.

Solid rectangular plates are loaded simultaneously by pure twisting and bending moments at one of the two shorter curved ends. Relations between deflections and applied moments are nonlinear and are characterized by instabilities which arise as a result of chordwise deflection. The stress resultants in the chordwise direction are assumed zero. Selecting a parabolic camber, author deduces a solution of the problem. Some of the equations reduce to formulas previously presented by Ashwell for instability in large deflections of cambered plates and by Reissner for instability during finite bending and twisting of flat plates. Experiments are described which corroborate the theoretical trends.

S. T. A. Odman, Sweden

3339. Bartolozzi, G., The elastic stability of a longitudinally stiffened flat panel under axial compression (in Italian), *Aerotecnica* **38**, 6, 301–308, Dec. 1958.-

3340. Tolokonnikov, L. A., Critical pressures on a circular plate (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 77–86, Oct. 1958.

Case of clamped edge under uniform radial pressure with axisymmetric buckling is considered. Author notes that for given pressure there exists a sufficiently small thickness-to-radius ratio which guarantees elastic buckling. For an intermediate ratio, buckling is elasto-plastic. For a sufficiently large ratio, buckling does not occur. Limiting thickness ratio for no buckling cannot be determined from classical theory, which assumes deformations small compared to unity.

Using variational principle accounting for large deformations, expressions for thickness ratio corresponding to loss of stability for given pressure are deduced for elastic and elasto-plastic cases. As it should, result for elastic case agrees with classical formula of Dennik when thickness approaches zero.

Reviewer considers theoretical presentation sophisticated and results practical.

B. S. Wilson, USA

3341. Okumura, T., Theoretical and experimental study on the effective rigidity ratio of one-side stiffener (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **63**, 23–35, July 1959.

Stability of a rectangular plate welded vertically with stiffeners on one side and under the combined action of shear, tension and bending is examined. For one-side stiffening, torsional resistance and local contraction due to the eccentricity of the middle plane of the plate from the sectional center line of the stiffeners should be considered as the most important factors. Taking these factors into account, author calculates the effective rigidity ratio of one-side stiffeners by the so-called energy method, and compares the analytical results with his experiments.

From author's summary
*Courtesy of the Editorial Committee,
Japan Society of Civil Engineers*

3342. Nash, W. A., and Tang, C. N., An experimental investigation of the torsional buckling of initially imperfect cylindrical shells (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 32–41.

It is well known that the linearized buckling theory for cylindrical shells under torsion yields critical loads which are 30–40% higher than those found experimentally. Authors show that a much better agreement exists between large deflection theory as presented by Loo [Proc. of second U.S. Congr. of Appl. Mech. p. 345, 1954], Nash [Engng. and Industr. Exper. Stat. Rep., Univ. of Florida 1956], and experimental results if, additionally, imperfections of the unloaded shell are taken into account. Amazingly, the *number* of waves predicted by linear theory agrees well with experiments in all cases, though neither the angle nor the length do so. (Wavelength about 1/3 of length of cylinder.) Test apparatus and test procedure are carefully described; a table presents all results.

K. Marguerre, Germany

Vibrations of Solids

(See also Revs. 3241, 3258, 3301, 3360, 3397, 3469, 3657, 3772)

3343. Steidel, R. F., Jr., Strains induced in transmission-line cables by aeolian vibration, *Proc. Soc. Exp. Stress Anal.* **16**, 2, 109–118, 1959.

3344. Karamyshkin, V. V., Application of multihypergeometric functions to the determination of deflection shapes and frequencies of free vibrations of beams and shafts (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 134–136, Mar. 1958.

If the transverse shear deformation and rotatory inertia are not considered, the equation for a vibrating beam of variable cross section reduces to the equation for multihypergeometric series, provided that $I_0 = I_0 x^{2\mu+2\nu}$, $A = A_0 x^{2\nu}$, $x_0 \leqslant x \leqslant x_0 + l$ where μ and ν are arbitrary constants. This fact provides exact and approximate closed-form solutions for a wide variety of problems in the theories of vibrations and bending of beams. Unfortunately, no tables of multihypergeometric functions have been prepared.

R. Schmidt, USA

3345. Kimel, W. R., Raville, M. E., Kirmser, P. G., and Patel, M. P., Natural frequencies of vibration of simply supported sandwich beams, Proc. 4th Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 441–456.

Analysis allows for bending and tension in the isotropic, thin-plate facings. In the core, shear and normal stress perpendicular to the beam are treated, but normal stresses along the beam are ignored. The core material is assumed incompressible in the direction perpendicular to the facings. Theoretical results are obtained and compared to experiments on sandwich panels with aluminum facings of equal thickness. Moderately good agreement is found; discrepancies are attributed to the use of manufacturers' static data for the core shear modulus. Authors suggest that vibration studies similar to theirs be used for the nondestructive determination of core dynamic shear modulus.

J. L. Lubkin, USA

3346. Reismann, H., Forced vibrations of a circular plate, *ASME Trans.* **81** E (*J. Appl. Mech.*), **4**, 526–527, Dec. 1959.

Very brief paper derives formulas for deflections of a thin clamped circular plate subjected to forced vibration by action of arbitrarily located concentrated periodic (harmonic) force. Damping is not included. Solution involves classical techniques, concept of singularity at load point, and use of Bessel functions. Method, which can be extended to include damping and is applicable to other boundary conditions, should be of interest to those concerned with calculations of this kind.

C. W. Smith, USA

3347. Fialko, Iu. I., A study of torsional bending vibration in the blades of turbine machinery in a gas flow *(in Ukrainian)*, *Dopovidi Akad. Nauk URSR* no. 6, 548–551, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9681.

Linear equations are set up for the constrained torsional bending vibration of the blades of a turbine machine in a gas flow, taking into account the effects of natural twist internal resistance of the blades, centrifugal inertia forces and other factors. A system of three equations (bending vibrations in two places, and torsional vibration) is solved by two methods of asymptotic resolution [A. L. Goldenveiser, "Theory of thin elastic shells," Moscow, Gostekhizdat, 1953; I. R. Shtaerman, *Izv. Kievsk. politekn. i.-kh. in-ta*, **1**, 2, p. 75, 1924]. The calculations show the influence of individual parameters as well as the inter-related influences of parameters which have not been previously taken into consideration. The results confirm certain earlier facts established experimentally [P. M. Riz, S. G. Popov, Tekn. Zametki TsAGI, 1936, no. 135, 3].

S. G. Popov

Courtesy Referativnyi Zhurnal, USSR

3348. Krivtsov, Yu. V., and Pernik, A. D., Singing propellers (in Russian), *Sudostroyeniye* no. 10, 9–14, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9904.

Data on the singing of ship propellers are communicated, representing the results of investigations made recently at the A. N. Krylov Central Institute for Scientific Research. The experiments were made in a cavitation tunnel, and partially in the experimental tank. The modes of vibration of propeller blades at which singing takes place are described, related to the flow velocity, blade incidence, and the structural blade elements, as determined on airfoil models of actual propeller blades. Analysis of the collected data indicates the probability that the physical cause of the singing of propellers is to be sought in the shedding, from the trailing edge of the blade, of discrete vortices forming a Karman street, the frequency of shedding of the vortices being dependent on a constant value of the Strouhal number. When the speed is reached at which the frequency of shedding of the vortices approaches the natural frequency of vibration (of the blade), the amplitude of the blade vibrations is increased, and the blade begins to react on the shedding of the vortices, the frequency whereof becomes synchronized with the frequency of vibration of the blade. As the flow velocity increases to a value corresponding to the disappearance of singing, the energy of the flow increases to such an extent that the vibrating edge of the blade can no longer control the frequency of shedding of the vortices, which then changes discontinuously to a value corresponding to a constant Strouhal number. With further increase of the flow velocity, this process can be repeated each time that the shedding frequency approaches the natural frequency of vibration of the blade. The theory advanced agrees well with the experimentally observed facts.

I. V. Girs

Courtesy Referativnyi Zhurnal, USSR

3349. Heinrich, G., and Desoyer, K., About the adsorption of linear vibrations by means of the centrifugal pendulum (in German), *Ing.-Arch.* **28**, 79–88, Mar. 1959.

Author treats the problem of the forced vibrations of the mass mounted on a spring under the action of a periodic disturbing force produced by the machine unbalance. For the adsorption of these linear vibrations author uses a centrifugal pendulum attached to the machine shaft by means of a geared system. The same problem was solved by F. E. Reed [*J. Appl. Mech.* **16**, 2, 190–194, 1949], but in this paper the problem is enlarged, taking into consideration the damping and the effect of nonlinear terms. Assuming that angular velocity of the centrifugal pendulum is constant the governing differential equations of the system with three degrees of freedom are obtained by means of the Lagrange equations. The solution of these equations is supposed in the form of Fourier series in complex form, the coefficients of which are determined by means of the Galerkin method. The resonance case is also discussed. To illustrate the method one numerical example of the fundamental vibrations is treated.

D. Raskovic, Yugoslavia

3350. Polachek, M., Modern methods of solving the problem of free vibrations (in Russian), *Czech. Tyzh. Prom-st.* no. 3, 46–50, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9511.

A method is given of solving the problem of free vibrations in metal-cutting machine tools. The tool is considered as a linear system with damping. This system has a range of free vibrations of different frequency and shape. Each vibration is determined at the cutting point of the material by the following quantities: frequency of natural vibration Ω_k, co-efficient of fading λ_k, angle α_k, between the vector of the relative vibration X_k (between the cutter

and the work piece) and direction of the normal to the principal cutting edge of the tool N_k; angle β_k between vector X_k and vector of the cutting zone P, degree of yielding p_k, of the particular mode of vibration. These dynamic characteristics can be established by measuring the constrained vibrations of the machine tool by a special tensometer arrangement. Vibrations in the system are exerted by varying the force of an electromagnetic vibrator, acting between the cutting tool and the work piece. A sketch of the layout of the measuring apparatus is given. Applying the characteristics Ω_k, λ_k, p_k, α_k, a fundamental equation is set up expressing the relationship between the magnitude of the cutting zone and the periodical change in cross section of the chip, in which the variable component of the cutting force sets up complex vibrations in the oscillating system of the tool. These vibrations set up a periodic relative motion between the cutter and the work piece, which is the cause of the change in the cross section of the chip. The fundamental equation is

$$\sum_k p_k \cos \alpha_k \cos \beta_k \frac{\Omega_k^2}{\Omega_k^2 - (\omega - j\lambda_k)^2} = -\frac{1}{r(1 - e^{i\varphi})}$$

$$j = \sqrt{-1} \qquad [1]$$

where ω is the frequency of free vibration, φ phase angle, r coefficient of cutting depth, corresponding to a given thickness of the chip.

An important question is the determination of the limiting value of $r_{pred.}$ and ω at the boundary of stability of the system. This value can be found from the real part of equation [1]

$$\sum_k p_k \cos \alpha_k \cos \beta_k \Omega_k^2 \frac{\Omega_k^2 + \lambda_k^2 - \omega^2}{(\Omega_k^2 + \lambda_k^2 - \omega^2 \lambda_k^2} = -\frac{1}{2r} \qquad [2]$$

Results are given of an investigation of the limiting conditions for one kind of work on a column miller.

S. N. Shimanov
Courtesy Referativnyi Zhurnal, USSR

3351. Henry, R. F., and Tobias, S. A., Instability and steady-state coupled motions in vibration isolating suspensions, *J. Mech. Engng. Sci.* **1**, 1, 19–29, June 1959.

Paper concerns theoretical and experimental investigation for rigid body suspended symmetrically on frictionless nonlinear (stiffening) springs. Problem is of interest in vibration isolation. System of six degrees of freedom is broken down with considerable success to equivalent two-degree-of-freedom systems having equations of Mathieu type. Stability of motions is examined and charts are given. R. E. D. Bishop, England

3352. Frost, M. D., The inertial effects of springs in resonance and free oscillation experiments to determine damping, Aero. Res. Lab. Melbourne, Austral. Rep. A, 111, 45 pp., Jan. 1959.

Allowance for distributed mass in a helical spring, treated as a uniform bar, is calculated. Rather a heavy attack on a simple problem. D. C. Johnson, England

3353. Alterman, Z., Jarosch, H., and Pekeris, C. L., Oscillations of the earth, *Proc. Roy. Soc. Lond. (A)* **252**, 1268, 80–95, Aug. 1959.

A study is made of the free and forced oscillations of the earth. The natural periods are determined for radial, torsional and spheroidal types of oscillation. Several models of the earth are used; a homogeneous model, such as was assumed originally by Love, a model consisting of a homogeneous solid mantle enclosing a homogeneous liquid core, Bullen's model B and Bullard's models I and II. It is found that the spheroidal oscillation of order 2 has a period of about 53.5 min in all models, except the homogeneous one, for which this period is only 44.3 min. The common period of 53.5 min agrees to within the observational error with the period of 57 min observed by Benioff on the seismograms of the Kamchatka earthquake of 1952. In contrast to all the other models, Bullen's model B possesses an additional spheroidal oscillation of order 2 of a period of 101 min. The latter oscillation is confined mainly to the core, its amplitude in the mantle being relatively very small. Benioff's observation of a second oscillation of a 100-min period in the Kamchatka earthquake record might be considered as evidence favoring Bullen's model B. The latter differs from Bullard's models mainly by having a central density of around 18 instead of about 12 g/cm^3. However, a theoretical investigation of the relative excitation of the various free models by an impulsive compressional point-source situated at a shallow focal depth shows that the amplitude of the 100-min oscillation should be less than one-one thousandth that of the 53.5 min oscillation. It is thus not clear how a near-surface earthquake could have excited the core oscillation.

The spectrum of the free modes of oscillation has also been determined for $n = 3$ and 4, including the fundamental and the first two overtones for each case. The computed free periods of spheroidal oscillation range from 53.5 min down to a period of 8 min for the fourth overtone in the case $n = 2$. Authors also treat the body tides for Bullen's and Bullard's models. Love's numbers were determined in the case $n = 2$ for tidal periods of 6, $6\sqrt{2}$, 12 and ∞ hours. The dependence of the Love numbers on the period is small, a maximum range of variation of 13% occurring in the k values between the periods of 6hr^3 and ∞.

From authors' summary by Y. Sato, Japan

Wave Motion and Impact in Solids

(See also Revs. 3291, 3300, 3301, 3353, 3383, 3397, 3712, 3747)

3354. Sternberg, E., and Chakravorty, J. G., On the propagation of shock waves in a nonhomogeneous elastic medium, *ASME Trans.* **81** E (*J. Appl. Mech.*), 4, 528–536, Dec. 1959.

Authors consider a nonhomogeneous plate of infinite extent and arbitrary thickness with a cylindrical hole. They assume Young's modulus an arbitrary function of radial distance r from the axis of the hole and shear modulus proportional to r^{α}(either integral or not). Authors resolve the equation for propagation of shock waves in the plate produced by uniform shearing on the boundary of the hole. The solution is obtained using Laplace's transformation and numerical solution of Volterra's integral equation; for particular α the solution is given exactly and in terms of elementary functions. For $\alpha < 2$ the solution asymptotically approaches to the solution of equilibrium state, for $\alpha > 2$ the solution ceases to be physically significant. R. Nardini, Italy

3355. Broberg, K. B., A problem on stress waves in an infinite elastic plate, Trans. Roy. Inst. Technol., Stockholm no. 139, 27 pp., 1959.

The problem considered is that of an infinite isotropic elastic plate to which a transverse impulsive load has been applied. Starting with the Pochhammer-Chree equations of motion and using the Laplace transform technique, the author is able to solve for the displacement of a point on the lower surface of the plate opposite the point of load application. The difficult problem of inverting the transform solution is overcome by a method introduced by Caignard ["Reflexion et refraction des ondes seismiques progressives—Gauthier-Villars," Paris, 1939]. The method consists essentially of expanding a portion of the inversion integrand in a power series. When this has been properly done the integrand takes a form which makes it possible to invert the transform by

inspection. Author not only obtains a formal solution to the problem but also computes numerical results for the impacts of small steel balls on a steel plate and compares computed with experimental results. The agreement is remarkably good, although the experimental displacements are slightly greater than those obtained by computation. Author suggests that the discrepancy may be due to a fault in calibration. The experimental work is described in an earlier publication [Broberg, "Shock waves in elastic and elastic-plastic media," Kungl. Fortifikationsförvaltningen Befästningsbyran Rap. 109-12, 1956; AMR **10**(1957), Rev. 1023].

A solution for the stresses in this same problem has recently been obtained by Davids [*Trans. ASME* **81** E (*J. Appl. Mech.*), 4, p. 651, Dec. 1959] following essentially the same method used by the author.

In an appendix, author presents a solution to the somewhat less practical problem of an infinite elastic plate subjected to a transverse impulsive line load.

This paper, inasmuch as it presents a usable solution to a difficult practical problem, is a significant contribution in stress wave propagation and the related subject of scabbing.

E. A. Ripperger, USA

3356. Mentel, T. J., The plastic deformation due to impact of a cantilever beam with an attached tip mass, *J. Appl. Mech.* **25**, 4, 515-524, Dec. 1958.

Impact tests on cantilever beams of low-carbon steel with masses attached to the free end are analyzed on the basis of ideal rigid-plastic behavior. The impact was applied by giving the built-in end of the beam a known acceleration. Preliminary analysis based on a yield stress of 30,000 psi and no work-hardening produced calculated deflections that were too high. When the theory was corrected to account for work-hardening of the material and for a strain-rate effect the calculated results were in good agreement with those obtained by experiment. E. A. Davis, USA

3357. Cox, A. D., and Morland, L. W., Dynamic plastic deformations of simply-supported square plates, *J. Mech. Phys. Solids* **7**, 4, 229-241, Oct. 1959.

Johansen yield criterion is used as an approximation to that of Tresca in work based on that of Hopkins [*Proc. Roy. Soc. Lond.* (*A*) **241**, 153-179, 1957]. Solutions for normal deflection are presented for rectangular pulse of uniform pressure in two ranges of magnitude and for impulsive uniform pressure. Results are extended for regular polygonal and for circular plates and are in agreement where comparison is possible with other work.

K. H. Griffin, England

3358. Perzyna, P., Dynamic load-carrying capacity of a circular plate (in English), *Arch. Mech. Stos.* **10**, 5, 645-647, 1958.

The problem of dynamic load-carrying capacity is solved for a thin circular plate simply supported on the periphery. The assumptions are as follows: (1) The plate is loaded with a time-variable pressure $p(t)$ uniformly distributed over the surface; (2) the material is rigid-plastic, the relation between the circumferential and radial bending moment, determining the plastic behavior, being assumed in the form of the Tresca hexagon.

The solution procedure depends on the maximum pressure P_m. For $p_0 < p_m < 2p_0$ (where $p_0 = 6M_0/R^2$, M_0 denoting the bending moment for which the plate becomes plastic), the radial bending moment is determined as well as deflections and deflection rates at any point and time and for any integrable function $p(t)$.

For the case $p_m > 2p_0$ the solution is limited to pressures of the explosion type satisfying the condition:

$$\int_0^t p(t)\, dt \geqslant t\, p(t)$$

In this case the motion of the plate is composed of two or three phases, each being described by a different equation. For the first phase, results of other authors are quoted. For the second phase the radial bending moment is determined as well as displacements of plate points; for the third, the displacement of the center of the plate and the time after which the motion of the plate ceases.

Numerical examples show that the influence of the character of the function (p/t) on the final deflection of the plate is, with the condition

$$\int_0^\infty p(t)\, dt = \text{const}$$

small and decreases with increasing p_m/p_0 ratio.

M. Piątek, Poland

3359. Hodge, P. G., Jr., The effect of end conditions of the dynamic loading of plastic shells, *J. Mech. Phys. Solids* **7**, 4, 258-263, Oct. 1959.

Paper extends work of AMR **9**(1956), Rev. 420 to obtain maximum radial deformations for case of long shells under moderate and high pressure. It is shown that for practically important range of finite shell length the maximum deformation is effectively independent of of this length. K. H. Griffin, England

3360. O'Bryan, T. C., and Hatch, H. G., Jr., Limited investigation of crushable structures for acceleration protection of occupants of vehicles at low impact speeds, NASA TN D-158, 24 pp., Oct. 1959.

A limited investigation has been made to determine the characteristics of three materials to see how they can be applied for human protection against accelerations encountered at low impact speeds. As a result, if given man's physiological tolerance to abrupt acceleration, which has not yet been well defined, an alleviation system can be designed.

Formed plastics require considerable depth to provide a given stopping distance for impact alleviation and their use would require some control of rebound. They can be made soft enough to obtain the low onset of acceleration that may be necessary for man where depth is not limited.

Aluminum honeycomb is an efficient material for impact load alleviation from the standpoint of usable material depth and it exhibits very little rebound. The stiffness of the material results in a very high initial onset rate of acceleration. For many installations this may be controlled by reducing the initial loading area of contact to get the material to start failing.

From authors' summary

3361. Batterson, S. A., Braking and landing tests on some new types of airplane landing mats and membranes, NASA TN D-154, 41 pp., Oct. 1959.

An experimental investigation was made at the Langley landing-loads track to obtain friction coefficients developed during braking and landing on various types of metal landing mats and prefabricated membranes. The tests were made at forward speeds of about 85 knots with static vertical loads of 20,405 and 13,020 pounds. The results indicate the effect of each type of mat and membrane on the variation of the coefficient of friction. Braking tests were made for both dry and wet surface conditions.

From author's summary

3362. Elmer, G. D., Design formulas for yielding shock mounts, David W. Taylor Mod. Basin Rep. 1287, 16 pp., Jan. 1959.

Design formulas are given for both the elastic characteristics and the plastic limit loads for three different configurations of yielding shock mounts. In addition, the behavior of these mounts is discussed, and a sample design computation is carried out. The satisfactory performance of a mount of this type during a field test is also briefly cited. From author's summary

3363. Summers, J. L., and Niehaus, W. R., A preliminary investigation of the penetration of slender metal rods in thick metal targets, NASA TN D-137, 9 pp., Dec. 1959.

Slender steel and tungsten-carbide rods were fired into copper, lead, and steel targets at velocities to about 11,000 feet per second. Values for the fineness ratio of the rods ranged from 6.0 to 12.7. For copper and lead targets, the impact is described as occurring in the undeformed-projectile region at the lower impact velocities and in the transition region at the higher velocities. For steel rods impacting steel targets, the impacts were described as occurring in the undeformed-projectile region of impact at all test velocities.

Rods impacting at velocities approaching the fluid-impact region were compared with the jets of shaped explosive charges. It was found that a rod produced a crater of twice the depth of that produced by a shaped-charge jet the same length as the rod. Furthermore, the craters produced by the rods were relatively wide cavities, with diameters comparable to depth, in contrast to the narrow holes formed by the jets. These differences are ascribed to increased secondary penetration for the rod impact, brought about by the low fineness ratio of the rods (10) compared to the jets (100).

From authors' summary

Soil Mechanics: Fundamental

(See also Revs. 3435, 3733)

3364. McNabb, A., A mathematical treatment of one-dimensional soil consolidation, *Quart. Appl. Math.* **17,** 4, 337–347, Jan. 1960.

Author gives a more general mathematical treatment of consolidation theory. Terzaghi's approximations (that the void ratio bears a linear relationship to effective pressure, and that the coefficient of consolidation does not vary during a loading cycle) are avoided. Instead, the general differential equation is linearized by assuming a more general relationship between pressure, void ratio, coefficient of consolidation and time, the coefficients of which may be determined experimentally. With the usual boundary conditions, this leads to a solution which contains a secondary consolidation term. Consideration of the case where void ratio initially varies along the axis of the specimen leads to a result showing a form of pre-primary consolidation, shown by initial departure from linearity in the relationship between consolidation and (time)$^{1/2}$. Results, not dissimilar in general form and derived from a more empirical approach to the same problem, have been given by D. W. Taylor ["Research on the consolidation of clays"—M.I.T., 1942]. Only one of Taylor's theories (that of accounting for secondary compression) is referred to by the author. Reviewer believes that closer comparison with the earlier work could have been advantageous.

Cases of uniformly increasing pressure, and of compressible particles are also considered.

P. W. Taylor, New Zealand

3365. Yamaguchi, H., Application of Kotter equation to theoretical soil mechanics (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **65,** 1–9, Nov. 1959.

A reasonable method of analysis for earth pressure computation and bearing value estimation is presented by solving difference forms of the generalized Kötter equations. Developing Ohde's method an approximate method of analysis for earth pressure on a wall rotating around its upper end is discussed, and these theories are compared with experiments. Through these investigations it has been shown that usual approximate formulas have fairly good accuracy with respect to the pressure intensity, except the passive case, when an angle of internal friction exceeds 40 degrees, and that the pattern of the slip-line field given by them is, however, considerably erroneous. Finally, a correction method for obtaining a stability number more accurate than Jaky's values is presented.

From author's summary

Courtesy of the Editorial Committee, Japan Society of Civil Engineers

3366. Thurston, C. W., and Deresiewicz, H., Analysis of a compression test of a model of a granular medium, *ASME Trans.* **81**E (*J. Appl. Mech.*), 2, 251–258, June 1959.

Theory is based on rhombohedral packing of identical spheres, i.e. in densest possible packing with 26.0% porosity. Duffy and Mindlin's incremental stress-strain relations, based on Hertz equations, are integrated for loading consisting of deviator stress added to initial isotropic (hydrostatic) stress. At failure, ratio of axial stress to initial isotropic stress is shown to be $(\sqrt{6} + 8f)$ $(\sqrt{6} - 4f)$, where f is coefficient of friction between spheres.

Experimental results obtained on $\frac{1}{4}$-in. stainless steel balls forming a bar, with isotropic stresses up to 1 atmosphere, showed reasonable agreement with two predicted stress-strain curves.

Reviewer notes that: (1) Measured failure stresses show that f falls as the isotropic stress is increased. (2) Results emphasize how very different tan ϕ is from the value of f for intergranular contacts.

Paper's value would have been enhanced by a calculation of the proportion of the failure stress which is due to dilatancy (a proportion which becomes large when f is small).

T. K. Chaplin, England

3367. Gamal Eldin, A. K., Study of the relation between the shearing resistance and the compressibility of normally consolidated clays (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24,** 1/2, 129–155, 1959.

The paper demonstrates—on the basis of shear and compression-tests carried out with sensitive materials—a relation between the shearing strength and the compressibility. Theoretical examinations and test-results proved that, representing the logarithm of the shearing strength as a function of the void-ratio of a saturated soil, a straight line is obtained which is parallel to the straight line representing the relation between the void-ratio and the compression-stress.

The shearing strength is directly proportional to the consolidation-stress, i.e., to the preload, and is further a function of the real, interior friction angle of the clay, and of the coefficients of compressibility and of swelling.

The shearing stress of a clay which has been consolidated in an isotropic manner—$\sigma_1 = \sigma_2 = \sigma_3$—in a triaxial cell is, for the same consolidation stress preload, higher than the shearing stress of such a clay consolidated in an anisotropic way—$\sigma_1 > \sigma_2 = \sigma_3$—in a consolidation apparatus. In the first case the void ratio diminishes considerably, and no shearing stress is mobilized.

From author's summary

3368. Thuronyi, G., Annotated bibliography of recent literature on soil moisture, *Meteorol. Abstr.,* **10,** 3, 423–461 Mar. 1959.

Soil Mechanics: Applied

(See also Revs. 3364, 3417, 3741)

3369. Szechy, Ch., Tests with tubular piles (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24,** 1/2, 181–219, 1959.

Author describes the tests executed with driven steel tubes, with a view to checking the bearing capacity of hollow tubes as compared with the economy obtained in driving energy. He has demonstrated that with a gradual building up of a resistant inner earth core about the same bearing capacity was obtained as for

solid piles, but a great economy was secured in the driving energy, at the price of settlements. The tests have manifested further items as to the unreliability of various driving formulas, proving that driving energy cannot be regarded as a true measure of pile bearing capacity. A fairly good correlation was found with the extruded soil-mass and on this basis the author develops a new statical pile bearing formula, demonstrating also the superiority of driven piles as compared to bore-piles. Finally, he introduces some field test results proving the value of the tests and demonstrating an economy of 30-50% in driving energy and about 30% saving in material with the assurance of the same bearing capacity. From author's summary

3370. Meyer, O. H., Computation of the stability of slopes, *Proc. Amer. Soc. Civ. Engrs.* **84,** SM 4, Part I (*J. Soil Mech. Div.*), Pap. 1824, 12 pp., Oct. 1958.

The study of the stability of earth slopes is carried out on the basis of the well-known Swedish method. The rupture is assumed to occur along a circular arch, and easily applicable formulas are given to determine the factor of safety along any sliding arch and the minimum factor along the critical arch. The case of nonhomogeneous earth and the effect of seepage are also considered.

Although not introducing any novelty in the theoretical treatment of the problem, the results presented in the paper may be useful in practical design. P. L. Romita, Italy

Processing of Metals and Other Materials

Book—3371. Feldmann, H. D., Extrusion of steel [Fliesspressen von Stahl], Berlin, Springer-Verlag, 1959, viii + 208 pp. DM 31.50

Book is written primarily for production engineers concerned with extrusion techniques for steels. A brief historical summary is followed by a chapter on theory of plastic deformation and energy requirements for extrusions of various geometric configurations. The effects of metallurgical structure, fiber orientations, heat treatments and mechanical properties of various steel alloys are discussed in great detail. A number of numerical examples are presented and the book is completed with illustrations of different extrusion machinery and equipment as well as a discussion of manufacturing techniques. A bibliography, limited with regard to fundamental research in plastic flow as applied to extruding, has been included. J. Frisch, USA

3372. Wistreich, J. G., and Shutt, A., Theoretical analysis of bloom and billet forging, *J. Iron Steel Inst., Lond.* **193,** 2, 163-176, Oct. 1959.

A theory is developed for the press cogging of square blooms and billets by means of flat tools in order to find the best working procedure for use in a mechanized press forge. In general, it was found that the most efficient procedures are those in which both squeeze and feed increments are progressively changed in proportion to the current height and width of the piece, so that its cross section alternates between the square and one rectangular shape. B. W. Shaffer, USA

3373. Boulger, F. W., 1958 review of metal processing literature (plastic working), ASME Prod. Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-5, 3 pp.

3374. Engstrand, G., Use of radioactive isotopes for measurement of cutting tool wear, Trans. Roy. Inst. Technol., Stockholm, no. 143 (Mech. Engng. no. 4), 17 pp., 1959.

Paper deals with methods and applications of the isotope technics in determination of wear resistance of cutting tools. Relative measurements have been performed by means of a scintillation detector. From author's summary

3375. Kuznetsov, V. D., Loskutov, A. I., and Pavlova, S. N., The work hardening of metals in cutting with a lubricant, *Soviet Phys.-Doklady* **3,** 6, 1238-1241, June 1959. (Translation of *Doklady Akad. Nauk SSSR* (*N.S.*) **123,** 2, 272-274, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

3376. Sato, K., An analytical study on grinding resistance, *Technol. Rep. Tohoku Univ.* **21,** 1, 147-177, 1956.

Author reviews previous research on grinding resistance and discusses experimental results published by Schlesinger, Kurrein, Sekiguchi, Ebihara, Takenaka, Boston, Shaw, Watanabe and Ono. Using geometrical analysis, author calculates mean cutting force acting on a single grit for several grain shapes, also the mean depth of cut and number of cutting points in action. Formulas for normal and tangential grinding resistances are presented (assuming specific grinding resistance is given by tangential force per unit chip cross section). Grinding resistances of various wheels were measured, showing specific grinding resistance to vary inversely to mean depth of cut and this result is in agreement with data calculated from experimental results reported by previous investigators. Author suggests that when specific grinding resistance for given material is established experimentally, grinding resistance can be computed for known wheels and grinding conditions. Watanabe and Ono published formulas for grinding resistance which do not seem to differ appreciably from author's analysis on this subject. S. Eilon, England

3377. Szoke, B., Should grinding rolls of different diameters be operated together? (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24,** 1/2, 3-44, 1959.

Author investigates the grinding, operating, mechanical and economic conditions bearing on pairs of rolls where the diameter of one roll = D, the diameter of the other roll = $D_1 = kD$ and where $k < 1$. Taking $k = 1$, the formulas known for almost a century have been obtained from the *generalized relations.*

The investigations show that the grinding of wheat and other grain, if considered from the points of view of pulling-in, grinding path and crushing with the usual diameter D, the reduction factor $k < 1$ is permissible and holds many operational and economic advantages. (This factor gives the diameter D_1, suitable for considerations of strength and rigidity.)

Assuming that the relative speed of the rolls is the same, the breaking of the berry takes place more cautiously, the gear tooth pressure is smaller, meshing is improved and the total number of teeth is smaller, the weight of the pair of rolls, the space required by the roller mill and its cost of production are all lower. From author's summary

3378. Reichenbach, G., 1958 review of metal processing literature (grinding), ASME Prod. Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-4, 3 pp.

Book—3379. Laeis, M. E., Die casting of thermoplastic materials [Der Spritzguss thermoplastischer Massen], 2nd new enlarged ed., Munchen, Carl Hanser Verlag, 1959, 301 pp. DM 29.

Following the dynamic development of synthetic resins, the die casting or injection molding process has found widespread application the world over. After defining injection molding and brief historical review, author describes in detail construction and operation of commercially available machines. Types are covered by countries of origin, both pictorially and verbally. Subsequent chapters treat the design of dies, especially those requiring under-

cuts, and the materials amenable to injection molding, called "macro-molecular organic compounds."

A detailed list of trade names and manufacturers is included; this tabulation is comprehensive and valuable.

Final chapters include manufacturing techniques and directions for correct design. In an appendix is found a review of patents dating from 1872.

This reviewer found the bibliography and index wanting in adequate coverage. However, this is a minor shortcoming of a good reference book providing a general review of the present-day state of the art. It is written in layman's language; knowledge of the subject is not a prerequisite.

The book is *not* a technical manual but emphasizes economics of the process and equipment described. H. J. Heine, USA

Fracture (Including Fatigue)

(See also Revs. 3289, 3391, 3396, 3401, 3405, 3614)

Book—3380. Averbach, B. L., Felbeck, D. K., Hahn, G. T., and Thomas, D. A., Fracture (Proc. International Conference on Atomic Mechanisms of Fracture, Swampscott, Mass., Apr. 12-16, 1959), New York, John Wiley & Sons, Inc., 1959, xvii + 646 pp. $17.50.

The scope of the Conference is stated in the Foreword to cover "... fracture phenomena in metals, ceramics and polymers, and the mechanism operating in cleavage, fatigue, ductile and high-temperature fractures. At the same time the scope of the Conference was limited by excluding the large and important field of engineering fracture mechanics on the basis that this topic could best be considered at a separate conference." Although this last limitation may be true in regard to the many variables which determine the fracturing of engineering materials, it is somewhat surprising to learn from this conference report that the mechanics of the solid continuum is still governing most quantitative thinking in this area. The conference report contains 27 papers and three short summaries of the various sessions preceding the papers (designated as paper 1, p. 1 to 19). Over one half of the number of papers are contributions from researchers in England, Australia, France and Germany.

The following papers can be considered to be of particular interest in the field of the AMR, offering more general discussions of the many facets of fracture presented in most of the contributions: Nos. 2, 7, 12, 14, 15, 16, 17 and 24. It is impossible to cover the content of the book in any detail, as each paper presents an abstract of a considerable amount of research effort to which the author has contributed to some extent.

Nearly two thirds of the 27 papers presented deal with metals and one third with nonmetallic materials (glass, plastics, ceramics), with a few papers discussing the theories of failures in general. The bulk of the experimental contributions on metals concerns three topics, namely (a) the transition from the ductile to the brittle condition on decrease in testing temperature and the mechanism of cleavage failures in crystals, (b) the deformations of the grain structure occurring in fatigue, and (c) the deformation of the grain structure occurring in creep. The theoretical treatments relate primarily to crack initiation and crack propagation.

Most of the theories advanced up to date on crack propagation are modifications of Griffith's theory, but none of these seem to conform well to test results. Crack initiation remains little understood. Although considerable hope is expressed that atomistic theories "... can lead to a quantitative prediction of behavior ...," "... the road is long, dark and treacherous ...."

G. Sachs, USA

3381. McClintock, F. A., Ductile fracture instability in shear, *J. Appl. Mech.* **25,** 4, 582-588, Dec. 1958.

It is postulated that fracture occurs in an elastic-plastic non-work-hardening material subject to pure shear when a critical shear strain is attained throughout a critical volume of material. The plastic strain at the tip of a crack is related to the size of the plastic region ahead of the crack. An attempt is made to balance the strengthening effect of the plastic flow against the detrimental effect of crack growth. E. A. Davis, USA

3382. Lavrov, V. V., The nature of the scale effect in ice and strength of the ice sheet, *Soviet Phys.-Doklady* **3,** 2, 934-937, May 1959. (Translation of *Dokladî Akad. Nauk SSSR (N.S.)* **122,** 4, 570-574, Oct. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author treats the bending of a beam with a surface defect and shows that, for his assumptions, the scale or size effect can be obtained. His assumption that the absolute elongation of the outer fiber is concentrated at the point defect disregards the fact that the defect is parallel with the surrounding elastic material and is constrained to deform with it. The stress gradient in the thickness direction results in a larger stress at the base of the defect for thicker specimens but does not account for the size effect observed. Reviewer believes that the Griffith crack theory is a more realistic approach to this problem and will yield good agreement with the data. M. J. Manjoine, USA

3383. Ripperger, E. A., and Barton, W. R., Dynamic loading tests of an aircraft-type beam, *ASME Trans.* **81** E (*J. Appl. Mech.*), 3, 357-366, Sept. 1959.

Arrested-drop tests were conducted on simplified box-type wing structures to determine loads, deflections, accelerations and strains, as well as times of failure or maximum strain. Latter ranged from 20 to 40 millisec. Failure occurred at roughly same loads and deflections as observed in previous static tests. Analog computer solutions, based on simplified equations of motion and static load-deflection relationship for structure, showed fair agreement with test results for deflections, generally poor agreement for accelerations. F. J. Plantema, Holland

3384. Yokobori, T., Fatigue fracture criterion in metals based on dislocation theory, *Technol. Rep. Tohoku Univ.* **22,** 1, 51-61, 1957.

Assuming cracks initiated by dislocation pile-ups, a theory is proposed for fatigue strength under combined alternating bending and torsion. An important parameter is the mean free path of slip *L* (distance from source to pile-up). The theory can be made to fit available data on carbon steels, cast iron and brass. It is proposed that *L* is determined by grain size in low-carbon steels, by mean ferrite path in medium-carbon steels, and sometimes by inclusion spacing in dirty steels. Author suggests that ductile static failure differs from fatigue failure in that many more dislocation sources are activated in the first case.

J. M. Frankland, USA

3385. Vagapov, R. D., Khripina, L. A., and Shishorina, O. I., Estimate of fatigue strength of large-size structural elements, using test results on model specimens (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 15-23, July 1958.

Problem of size effect in shafts and other structural members is considered. The "size effect" is shown to be determined by the strength level of the steel and the variation of the stress gradient in the specimen. The fatigue strength is higher for the conditions where the stress gradient is large. High-strength steels (250,000 psi yield strength) are less susceptible to the size effect. These concepts are also used to compare results of push-pull and rotating-beam fatigue tests. Stress gradient parameters are used in calculating actual behavior from model results. It is emphasized that an elastic-plastic solution of the problem would be desirable.

R. W. Guard, USA

3386. Signorelli, R. A., Johnston, J. R., and Weeton, J. W., Thermal-stress fatigue cracking of turbine buckets operated at 1700 °F in a turbojet engine with frequent starts and stops, NASA TN D-125, 16 pp., Oct. 1959.

Five high-strength nickel-base bucket materials were tested in a J47 turbojet engine at 1700 F. The investigation was conducted to study the effects of advanced-temperature operation on thermal-stress fatigue resistance of several of the newer turbine-bucket alloys. Inadvertently, the buckets were subjected to frequent starts and stops during the test. The bucket materials used in the test were SEL-1, B and B, Inconel 713, cast Udimet 500, and wrought Udimet 500.

Thermal-stress fatigue cracking on the leading edge of the buckets was observed in all alloy groups after short operating times. Cracks occurred in some groups after only 10 starts (6½ hr at rated speed) and had occurred in all groups after 28 starts (30 hr). At the conclusion of the test (49 starts and 70 hr), 60 to 90% of the buckets of each alloy had developed cracks. Thermal-stress fatigue cracks did not progress rapidly by stress-rupture to cause fracture of buckets. Only one bucket fractured during the test; a thermal-stress fatigue crack progressed by mechanical fatigue to fracture. This bucket was run with cracks for 31 hours before fracture. Other buckets ran with cracks for as long as 63 hours without fracture. From authors' summary

3387. Grover, H. J., Hyler, W. S., and Jackson, L. R., Fatigue strengths of aircraft materials—Axial-load fatigue tests on edge-notched sheet specimens of 2024-T3 and 7075-T6 aluminum alloys and of SAE 4130 steel with notch radii of 0.004 and 0.070 inch, NASA TN D-111, 25 pp., Sept. 1959.

Two edge-notched specimens were designed and tested, each having a theoretical stress-concentration factor $K_t = 4.0$. The radii of the notches were 0.004 and 0.070 inch. Tests of these specimens were run at two levels of nominal mean stress: 0 and 20,000 psi.

Results of these studies extend information previously reported on tests of specimens with varying notch severity. They afford data on the variation of fatigue-strength reduction with notch radius and on the potential usefulness of Neuber's technical stress-concentration factor K_n.

From authors' summary

3388. Behaviour of high temperature steel in fatigue experiment between 500–700 °C (in German), *Arch. Eisenhutten.* **28,** 11, 673–730, Nov. 1957.

3389. Doyle, W. M., and Jones, R. G., The atmospheric stress-corrosion resistance of some forged high strength aluminum alloys and an assessment of the effects of a step-quench into molten salt, *Aero. Quart.* **10,** 4, 297–318, Nov. 1959.

Since the introduction of aluminum-zinc-magnesium-copper alloys, investigations into the behavior of these high strength materials, over a wide range of composition, have indicated the significance of corrosion as a factor affecting the cracking of these alloys after prolonged stressing at loads below the ultimate tensile strength of the material.

Most of the previous work designed to assess the stress-corrosion resistance of aluminum-zinc-magnesium-copper alloys was carried out on sheet and plate material and the present investigation is concerned with the examination of these materials in the form of large hand-forged slabs, tested in the short transverse direction. In addition, tests have been carried out on an aluminum-copper-magnesium alloy conforming to B.S.S. L.65.

The effects of variations in heat-treatment procedure on stress-corrosion resistance have been determined on one selected alloy of the D.T.D. 683A type, and step-quenching in molten salt, following solution heat-treatment, has been shown to give maximum resistance to atmospheric stress-corrosion. The effects of this heat treatment on the residual stress, fatigue and tensile properties of forged material have also been determined.

From authors' summary

3390. Blythe, B. A., Miss, and Wright, W. W., Some results on the crazing of Perspex, including the effect of humidity, Aero. Res. Counc. Lond. Curr. Pap. 454, 19 pp., 1959.

The effect of humidity on the stress crazing of Perspex by four crazing agents has been investigated. A quantitative value for the change in threshold crazing stress with change in relative humidity has been derived.

A table of threshold crazing stresses for Perspex with a range of liquids has been compiled. From authors' summary

Experimental Stress Analysis

(See also Revs. 3310, 3320, 3345, 3397)

3391. Wells, A. A., and Post, D., The dynamic stress distribution surrounding a running crack—a photoelastic analysis, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 69–92, 1958.

Paper describes a dynamic photoelastic study of the stress distribution in the vicinity of a running crack initiating at one edge of a plate specimen loaded in tension, the specimen made from CR-39 plastic. The Schardin multiple-spark technique was used to record the events on a stationary photographic plate. Using the photoelastic fringe multiplication method, it was possible to obtain a sufficient number of distinct fringes, with plate specimens only ¼ inch thick.

Correlative "static" tests were also run on slotted plate specimens, the ends of which were subjected to a constant displacement which was uniform across the width. These specimens were of various transverse slot-length-to-width-of-plate ratios. The static results were compared with those obtained from the dynamic specimens which were nicked at the edge to establish the point of initiation of the crack and loaded to fracture with increasing tension.

It was determined that, in the absence of inelastic effects, the dynamic stress distributions in the vicinity of the crack approximated those obtained from the static tests, and at greater distances from the crack the distributions approached those corresponding to constant load during fracture. The disturbance from a running crack in the specimen was found to grow uniformly in all directions proportionately to crack length, provided the external boundaries were sufficiently remote. It was found that, during the advanced stage of cracking, the average stress on the uncracked portion (ligament) of the specimen did not increase to a value greater than 1.5 times the value at the outset of cracking.

M. M. Lemcoe, USA

3392. Rydzewski, J. R., Experimental method of investigating stresses in buttress dams, *Brit. J. Appl. Phys.* **10,** 10, 465–469, Oct. 1959.

Brief survey of photoelastic methods of stress analysis of dams precedes detailed description of method used by author for investigating stress distribution in a buttress dam web of constant thickness, resting on elastic foundation. "Frozen-stress" technique was employed in which composite model of dam and foundation together with the impounded liquid was subjected to a centrifugal acceleration which amplified body forces and liquid pressures about 28 times. The model was analyzed in polariscope to obtain principal stresses and their directions. The sum of principal stresses was found from measurements of lateral extensions of model through use of special technique developed by author, which is specially useful in the case of low fringe orders.

Use was made of a Sigma comparator in conjunction with Matrix slip gages to obtain greater accuracy of lateral extensions.

It appears that "frozen-stress" method can be applied to models made of more than one material and that extensometer method can be made applicable for obtaining results of greater accuracy.

S. K. Ghaswala, India

3393. Hickson, V. M., A replica technique for measuring static strains, *J. Mech. Engng. Sci.* **1**, 2, 171–183, Sept. 1959.

A technique for the measurement of static strain is described. The principle of the method is as follows: Irregularly spaced net of fine scratches is put on the polished surface of the specimen or structure, and the scratches are recorded in the unloaded and loaded states by means of replication. For the replication material a fusible alloy is chosen and a specially contrived replica gun is used. On a replica pair relative displacements are measured and strain is calculated. Author says that measurements may be taken to an accuracy of at least one micron by visual microscope techniques.

The features of this method are that the use of irregularly spaced net simplifies the preparation of specimens, the record of scratches is preservable for months and the equipment for taking replica is handy, etc. The observation of scratches and calculation of strains, however, are rather complicated.

This method may be useful for the quantitative investigation of local strain distributions in full detail.

T. Kanazawa, Japan

3394. Nakayama, Y., and Endo, H., Diaphragm type air-micrometer. I, Static characteristics, *Bull. JSME* **2,** 6, 210–217, May 1959.

Authors have worked out a new air-micrometer having an air chamber which is partitioned from wall to wall with a corrugated diaphragm and in the center of which a small aperture is bored to serve as inlet or outlet throttle, depending on the direction of air flow. The characteristics of such an air-micrometer will represent the combination of the characteristics of an ordinary air-micrometer and deflecting characteristics of the diaphragm. If a large magnification is provided for the air-micrometer, the nonlinearity of its characteristic may be ignored. As a result, there will be a linear characteristic over the wide range of measurement.

From authors' summary

3395. Becker, L. A., and Duffy, D. J., Strength of antipitching fins and ship motions measured on USS Compass Island (EAG 153), David W. Taylor Mod. Basin Rep. 1282, 23 pp., Apr. 1959.

Strains and pressures were measured in the antipitching fins on USS Compass Island (EAG 153) and were correlated with simultaneous measurements of sea state and ship motions.

A maximum principal stress of 14,000 psi was obtained when the fins slammed in a State 6 head sea at a ship speed of 18.8 knots. As a result of this slam, the peak pressure measured on the fin was 72 psi. It is concluded that the strength of the fins is ample.

The above condition was the most severe encountered and caused a maximum vertical acceleration at the bow of ±0.64 g, amidships acceleration of ±0.26 g, and a maximum pitch angle of ±6½ degrees. It is noted that both vertical and horizontal modes of vibration of the ship's hull were excited.

As a secondary objective, the effectiveness of the fins in reducing ship motions is analyzed. While some reduction in pitch is indicated, it is believed that duplicate trials with and without fins are required to obtain conclusive results.

From authors' summary

3396. Ogibalov, P. M., Testing of thick-walled tubes under high, short-duration, internal pressures (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 134–139, Sept. 1958.

Material Test Techniques

(See also Revs. 3309, 3391, 3602)

3397. Girard, F., New method for the measurement of the Poisson ratio (in French), ONERA Pub. 72, 19–24, Sept./Oct. 1959.

New method proposed by author for determination of Poisson's ratio consists of comparing the fundamental frequencies of longitudinal vibration for thin and thick solid circular cylinders. For thin cylinders (rod) this value is independent of ν ($N_0 = E^{1/2}/2L\rho^{1/2}$); for thick cylinders N is a function of ν. Detailed derivation is presented for general solution of longitudinal vibration of thick cylinders. Method is demonstrated experimentally, and is shown not to suffer from imposition of elevated temperatures. Experimental values of E and ν are given for Al and Mg alloys over range of −200 C to 350 C and a Ti alloy over −200 C to 600 C.

N. A. Weil, USA

3398. Batteau, D. W., A device for the measurement of Young's modulus and Poisson's ratio, *Bull. Mech. Engng. Education* no. 13, 3 pp., Jan. 1958.

3399. Hughes, E. T., and Burstein, E. B., The evaluation of bond quality in honeycomb panels using ultrasonic surface wave techniques, *Nondestructive Testing* **17**, 6, 373–377, Nov./Dec. 1959.

Properties of Engineering Materials

(See Revs. 3306, 3345, 3388, 3389, 3397, 3602, 3773)

Structures: Simple

(See also Revs. 3230, 3310, 3315, 3332, 3337, 3341, 3383, 3638)

Book—3400. Binder, R., Statics [Statika], Bratislava, Slovenske Vydavatel'stvo Technickej Literatury, 1959, 486 pp. Kcs 33.50.

Book is meant as a textbook both for students and designers in mechanical engineering. The introductory chapters concern the fundamentals of theoretical statics with respect to the solution of practical applications. Method of explanation is based on the vector calculus, both in its symbolical and numerical or graphical form. The theory introduced is then applied to the solution of important practical examples such as three-hinged girders, plane- and space-lattice girders, center of gravity, equilibrium of an ideal inextensible fiber, friction of rigid bodies, systems of bodies with friction from bindings, influence lines and moving loads, etc. Special attention is devoted to the statical solution of mechanisms with friction, which, according to the pedagogical experience of the author, presents difficulties when studied.

Style of the book is very clear; numerous illustrative figures, solved examples and controlling questions at the end of each chapter facilitate the understanding of the subject. Book can be recommended as a very good textbook on statics for use in mechanical engineering.

V. Kopriva, Czechoslovakia

3401. Yonezawa, H., A study on the collapse load of grillage beams (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **65**, 10–15, Nov. 1959.

This paper presents a theoretical and experimental study of the collapse load of grillage beams, composed of two main beams and cross beams, subjected to transverse loading such as to produce bending and twisting moment in the main beams. Following results are obtained: (1) Formulas for obtaining the collapse load are de-

tived for the case when one of the main beams yields. (2) Relations between the collapse of the loaded main beam and that of the simultaneous collapse of the two main beams are clarified theoretically. (3) The theoretical results are proved to be valid by model experiments. From author's summary

Courtesy of the Editorial Committee, Japan Society of Civil Engineers

3402. Peredy, J., On a new minimum-problem of the technical theory of strength of materials (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24**, 3/4, 329-346, 1959.

In the Hungarian literature on the theory of strength of materials, again and again the idea emerges that statically redundant structures have to be solved on the basis of the following two principles:

I. The beam should be as a whole, and in all its parts, in equilibrium.

II. The distribution of the interior forces should offer the possibility for the most likely economic formation of the beam.

If a statically n-times indefinite structure has to be solved in compliance with the foregoing points of view, the following mathematical problem frequently emerges:

$$\int_L \left| y_0(P) + \sum_{i=1}^{i=n} y_i Y_i(P) \right| dL = \text{Min!}$$

The present paper deals with the solution of this problem, showing two possible methods for this purpose. Furthermore, it discusses the proof of the existence of any solution to the problem, and gives information as to the character of the solution. Finally, it shows the application of the mathematical procedure on examples taken from the technical theory on strength of materials: such as frame-constructions, truss-girders, beam-grids.

From author's summary

3403. Baker, A. L. L., Ultimate load theory for concrete frame analysis, *Proc. Amer. Soc. Civ. Engrs.* **85**, ST 9 (*J. Struct. Div.*), 1-29, Nov. 1959.

Paper deals with ultimate load design of concrete frames as systems of elastic members joined by perfectly plastic hinges. For each loading condition plastic hinges are to be assumed in positions favorable to the type of frame used. A great deal is left to the discretion of the designer who must make a preliminary design and improve it by the trial and adjustment calculations suggested in the paper. Author states that designer must have a good knowledge of elastic theory and the characteristic moment distributions of typical frames. He suggests that hinge positions must be assumed at sections of peak moment, and must have a moment of plastic resistance equal to, or less than, the estimated value for elastic conditions. A check of the final design is afforded by the condition of compatibility of the angle of discontinuity at the plastic hinge with the assumed direction of the plastic moment, and the condition that, except for the plastic hinges, the structure must be elastic. Formulas are given for the computation of the angles of discontinuity at the plastic hinges during every stage of the design. Adjustments for different loading conditions may result in over-reinforcement of some cross sections, including hinges, with respect to some loads. Author assumes that, in general, such over-reinforcement does not weaken the structure, which is probably true for most ordinary structures.

Also author discusses minimum values and theoretical assumptions for strength and deformation calculations of members and hinges, and the behavior of ultimate designs under working load. Experimental results are cited to substantiate the suggested design formulas. D. C. Gazis, USA

3404. Barth, R., The load distribution effect of cross ribs in reinforced concrete rib slabs (in German), *Bautechnik* **35**, 12, 462-467, Dec. 1958.

In a system composed of nine simply supported ribs and one, two or three cross ribs, bending moments and shearing forces are determined for a concentrated load applied in the center point and for a linear load acting along the middle rib. Results indicate that for a concentrated load the best distribution is obtained with one cross rib beneath the load. For linear load three cross ribs give best distribution. The distributional effect of cross ribs requires these to be sufficiently strong, as they must usually resist more than the ribs. Several diagrams and tables may be of help for practical applications. E. Rathgeb, Argentina

3405. Efsen, A., and Krenchel, H., Tensile cracks in reinforced concrete (in English), Laboratoriet for Bygningsteknik, Danmarks Tekniske Hojskole Meddelelse no. 9, 24 pp., 1959.

3406. Muckle, W., A note on plating stiffened in two directions at right-angles, *Shipbuilder* **66**, 618, 433-435, July 1959.

A method for the determination of deflections and stresses in right-angle beam grillage systems is proposed. The method is particularly applicable to cases in which a large number of beams are supported by only a few comparatively rigid girders at right angles to the beams. The deflection curve of the girders is represented by infinite series. The force exerted on the beams by the girders can be determined in terms of the common deflection at points of contact. An energy method is used in determining the coefficients of the infinite series. The particular problem of n simply supported beams with one central girder (also simply supported) is solved. Equations for bending moment in the beams for four different beam-girder stiffness ratios are given. The method is simple and well-suited to the type of problem for which it was conceived.

Several typographical and notational errors were detected.

M. E. Raville, USA

3407. Klapetek, F., Analysis of some multiply connected slabs by the method of finite differences (in Czech), *Stavebnicky Casopis* **6**, 3, 165-182, 1958.

3408. Javor, T., Analysis of skew slabs by the method of finite differences (in Czech), *Stavebnicky Casopis* **6**, 6, 348-382, 1958.

3409. Kulakov, V. F., Designing of frame constructions for erection in regions liable to earthquakes (in Russian), *Izv. Akad. Nauk TurkmSSR* no. 2, 30-38, 1957; *Ref. Zb. Mekh.* no. 10, 1958, Rev. 11755.

The changes in stresses and deformations are investigated for a ferroconcrete double-stage, single-span frame in relation to its size, and also to the adopted relations of loads and rigidities. Nine variants of such frames were computated, with constant span, height and cross-beam section, and with variable relations of height of stages and mass, and also with different correlations of rigidity for each variant, when the foundation effects a motion in accordance with the principle of a fading sinusoid. It was found that the distribution of rigidity along the braces does exert an appreciable influence on the deformation and forces appearing in the frame, while the distribution of rigidity over the stages should be carried out in such a way as to ensure that the velocity of increase of deformation should be proportional to the height of the frame. It was established that, outside the resonance zone, the frames are most favorably situated when they possess the maximum dynamic rigidity, while on approach to resonance, flexible constructions experience the least shear. It was shown that deformations of parts of the frame are directly proportional to the magnitude of the displacements of the foundation. When the whole load is located on the upper stages, the frame undergoes displacements which are smaller in the presence of resonance than in the region outside resonance.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR

3410. Kovar, A., Two-story space frame, Parts 1 and 2 (in Czech), *Stavebnicky Casopis* **6**, 4, 216–228, 1958; **6**, 5, 310–324, 1958.

3411. Poocza, A., Minimum weight of high tension towers loaded in torsion (in German), *Bautechnik* **35**, 10, 399–400, Oct. 1958.

The structure considered in this paper is a prismatic space truss of rectangular cross section; the four lateral faces of the structure are simple plane trusses. The extent of the structure is supposed to be limited in such a way that the cross section shall not exceed a circle of a fixed diameter. Design stresses of tension and compression bars are assumed to be equal. Taking into consideration no other load than torsion, the structure of minimum weight is found to be composed of cubic cells, i.e., the cross section of the structure is quadratic and all diagonal bars of the lateral faces form angles of 45 degrees with the vertical bars.

E. Seydel, Germany

3412. Worch, G., The sine-shaped arch (in German), *Bautechnik* **35**, 11, 429–431, Nov. 1958.

Following classical German literature (Beyer), the determination of displacements caused by redundancies in primary structure is developed for the sine-shaped arch. Application of Fourier's sine series in determining loading coefficients leads to interesting simplifications. E. P. Villarreal, Argentina

3413. Layrangues, P., Elastic deformations and stresses on a circular arch loaded with a constant normal and a uniformly distributed lateral force: Stability of the elastic equilibrium (in French), *Ann. Ponts Chaus.* **129**, 3, 323–344, May/June 1959.

Author investigates effect of constant internal compressive force along neutral fiber of circular arch of uniform cross section on deflections and stresses due to uniform load perpendicular to plane of arch. Small-deflection theory is used, taking into account lateral distortions of structure. Lateral stability of arch under internal compressive force is studied. Author suggests extensions to nonconstant cross section and internal compressive force might be made. Other extensions might be to include secondary effects of internal moment, shear force, and external load which may also be important to lateral deformation. P. Seide, USA

3414. Szmodits, K., Bending theory of flat spherical domes (in Hungarian), *Mélyépítéstudományi Szemle* **9**, 6, 294–296, June 1959.

Calculation method for flat domes with a brow capable of bending is presented. The new theory neglects those terms in the equation of condition which have no importance for flat domes and considers that moments take part in load bearing too. Charts are included of function values for circular symmetric load. Numeric example demonstrates use of the new method.

From author's summary

3415. Salmon, C. G., Schenker, L., and Johnston, B. G., Moment-rotation characteristics of column anchorages, *Trans. Amer. Soc. Civ. Engrs.* **122**, 132–154, 1957.

The presented characteristics are useful for analysis or design, particularly for cases in which resistance to rotation may be critical to the survival of the structure under heavy lateral loads such as earthquakes or blast loads. Upper and lower bounds for maximum resisting moment and maximum rotation, respectively, are developed. Shear is found to have little effect on the ultimate resisting moment but has somewhat more effect on the maximum rotation. Formulation of the complete moment-rotation curve is developed in five stages. Appendixes illustrate the use of the formulas. The variables involved are examined, and the effect of each on the ultimate moment and rotation is shown graphically.

From authors' summary by W. Wierzbicki, Poland

3416. Krishnan, S., and Shetty, K. V., Methods in optimum structural design for compression elements, *J. Aero. Soc. India* **11**, 2, 23–29, May 1959.

3417. Housner, G. W., Behavior of structures during earthquakes, *Proc. Amer. Soc. Civ. Engrs.* **85**, EM 4 (*J. Engng. Mech. Div.*), 109–129, Oct. 1959.

The performance of building structures during earthquakes depends upon the vibrations induced by the ground motions and the structures' ability to dissipate vibrational energy when overstressed. Response spectrum curves are useful to show the effect of size and distance of earthquakes and period and damping of structures. Using dynamic instead of static methods requires that structures be designed for lateral loads much larger than now prescribed by building codes. A reasonable compromise is to design structures to be damage-free for the more frequent, moderate ground motions but subject to some damage so long as it is not a hazard to life and limb for the more rare event of very strong ground motion. Existing codes based on observed damage do reflect the energy-absorbing properties of typical structures but are not suitable for non-typical and unusual structures. Test observations and advanced analysis are skillfully combined to satisfy most readers. E. G. Fischer, USA

Structures: Composite

(See also Revs. 3241, 3286, 3320, 3331, 3332, 3345, 3395, 3400, 3417, 3435)

Book—3418. Rusu, Gh., Technic of observations on massive structures [Tehnica Masuratorilor in Constructiile Masive], Bucarest, Academiei Republicii Populare Romine, 1958, 317 pp. Lei 25.90.

Book deals with the methods of observation in concrete dams (not in other structures as the title might suggest). The methods have been grouped in several chapters: measurements of deformations on the surface of the structure, those of deformations within the concrete, and those of the hydraulic effects; further the application of methods to different structures, and laboratory measurements. The principle of observation of deformations and stress is treated in detail both in theory and in the description of apparatuses, with reference to their manufacturer, so that the book will be of service to engineers. The measurements of uplift and the observations in other types of structures, e. g. galleries, are given less attention. The measurements of small-scale models are dealt with in detail.

The book contains a rich assortment of references, unfortunately not complete, e.g. a mention of observation on Italian dams is not included, as well as that from the reviewer's country that was given great attention. V. Mencl, Czechoslovakia

3419. Venetianer, L., On side-latticed crane bridges with box girder (in Hungarian), *Gép* **11**, 3, 102–109, Mar. 1959.

Author describes the crane bridges with box girder in widespread use throughout the United States and the Soviet Union, which have many advantages over the crane bridges with four lattice girders generally adopted in Europe. Because of some drawbacks inherent in the closed box section designs, it is a positive asset to have a structure with latticed or possibly framed outer wall instead of a plate girder. Paper deals with the analysis of structures of combined wall type, based on the idea of replacing the truss elements by an ideal web of thickness t_r. This t_r is determined by the deformation equality of the latticed girder and the ideal one. Then the torsional center of the obtained asymmetric closed section type beam is determined which is always situated outside the plate girder. Subsequent calculations are generally

known. The author then gives detailed information on model tests carried out at the Technical University of Budapest, where the measured stresses generally coincided with the calculated ones within a margin of 15%. I. Koranyi, Hungary

Machine Elements and Machine Design

(See also Revs. 3288, 3310, 3319, 3331, 3635, 3773)

Book—3420. Artobolevski, I. I., Theory of mechanisms for the reproducing of plane curves [Teoria mehanismov dlia vosproisvedenia ploskih krivyh], Moscow, Izdatelstvo Akademii Nauk SSSR, 1959, 255 pp.

Book presents the results of author's sustained scientific activity in the field and also extends the results obtained in U.S.S.R. and in various countries.

Proceeding from the most recent investigations on the theory of mechanisms which describe given paths, he emphasizes the part played by such mechanisms in the construction of various machines and automatic apparatuses through obtaining various functional dependences. The main novelty in the present treatment is the systematic use of both the analytical and geometrical methods.

Other problems discussed are: theory of mechanisms with higher pairs of the fourth class and that of mechanisms with lower pairs of the fifth class describing various curves and the theory and synthesis of exact rectilinear and circular guiding mechanisms.

Further, the mechanisms describing ellipses, hyperbolas and parabolas are dealt with. The theory of mechanisms describing second-order curves is also included.

The theory and synthesis of mechanisms reproducing algebraic curves of the fourth order and the theory of the mechanical reproducing of a class of curves higher than the fourth order are the subject of another chapter. Also included are problems pertaining to the synthesis of mechanisms reproducing usual transcendental curves as well as usual curves of high-order parabolic and hyperbolic type.

Reviewers believe that book is a valuable contribution in the field and fills a gap in a whole series of problems set by the construction of automatic machines.

D. Mangeron and R. Bogdan, Roumania

Book—3421. Artobolevski, I. I., Levitskii, N. I., and Cherkudinov, S. P., Synthesis of plane mechanisms [Sintez ploskih mehanismov], Moscow, Fismatgiz, 1959, 1084 pp.

This volume is an extension of the textbook "Synthesis of mechanisms" by Artobolevskii, Bloch and Dobrovolskii (Moscow 1944), including authors' new results as well as results obtained recently in various countries.

After an introduction devoted to the history of the synthesis of mechanisms, the comprehensive content is divided into three parts.

The first part (Chapters I and II) deals briefly with problems pertaining to the structure of mechanisms and to the kinematic geometry of mechanisms.

The second part (Chapters III–VIII) presents exact methods for the synthesis of mechanisms. Various mechanisms are discussed, such as: three-bar centroid mechanisms, four- or five-bar mechanisms with centroid rolling and sliding pairs, mechanisms with lower pairs, mechanisms describing conical curves, mechanisms describing high-order curves as well as mechanisms which reproduce certain functional dependences. Synthesis of cam mechanisms and of the so-called Malta Cross mechanisms is also included.

The third part (Chapters IX–XVI) concerns the theory of approximation methods. These chapters discuss the synthesis of transmission mechanisms, the synthesis of approximate guiding mechanisms and that of the transmission mechanisms by using the interpolation method or the best approximation method. Intermittent mechanisms are also dealt with. Both the geometric and the algebraic method are used.

A large number of references and a series of practical applications are given.

Reviewers believe that book represents a valuable contribution to the scientific literature. It may constitute a valuable guide to all those concerned with the subject.

D. Mangeron and R. Bogdan, Roumania

Book—3422. Mauri, H., Mechanism construction, Vol. I: Classification, problems and elements of mechanisms [Der Vorrichtungsbau, Ester teil: Einteilung, Aufgaben und Elements der Vorrichtungen], Berlin, Springer-Verlag, 1957, 70 pp. DM 3.60.

Book is one of a series of four dealing with mechanisms. Author first considers general classifications and interchangeability of main functions. Next the elements of mechanisms are systematically presented and discussed. The functions of mechanisms are listed as (A) Fastening, (B) Centering or Positioning, (C) Supporting, either fixed or mobile, (D) Fixing by means of protruding parts such as bolts, (E) Pressure distribution and diversion through screws, levers, and keys, (F) Enclosing, (G) Throwing, (H) Division and calibrating, (I) Supporting tools, (J) Guiding boring tools, (K) Cleaning and disposing of chips. A large number of properly selected figures makes it easier to understand the material presented. However, the compactness of the presentation may make it difficult for some readers to follow the author.

N. Theophanopoulos, Greece

3423. Meyer zur Capellen, W., Cycloidal curves and crank guide (in German), *Forscb. Geb. Ing.-Wes.* **24,** 6, 178–186, 1958.

Kinematic problems concerned with producing cycloidal curves, i.e. with rolling one wheel on another, are closely related to the kinematic processes of the crank guide. This analogy allows for transforming the results, gained with the crank guide, without important changes to the cycloidal movements. Formulas and procedures were established as functions of arc length, radius of curvature, velocity, and acceleration for epicycloids and hypocycloids as well as for the involute.

From author's summary

3424. Riftin, L. P., The kinematics of conoids and the selection of their geometry for the reproduction of a given function (in Russian), Teoriya i raschet elementov priborov tochnoi mekhaniki, Moscow-Leningrad, Mashgiz, 1957, 55–81; *Ref. Zb. Mekb.* no. 9, 1958, Rev. 9540.

A kinematic analysis of conoids as three-dimensional mechanisms with two degrees of freedom is performed by the usual vector method from given equations of surfaces and their motions.

On the question of selecting a conoid geometry for the reproduction of a given function, the following geometrical constants are calculated for each surface of the conoid: dimension of the conoid, angle of transmission, curvature of the surface and contact pressure. V. S. Lukshin

Courtesy Referativnyi Zburnal, USSR

3425. Groesberg, S. W., Designing a zero-gradient spring system, *Mach. Design* **32,** 2, 143–147, Jan. 1960.

3426. Schmidt, R., and Wempner, G. A., The nonlinear conical spring, *ASME Trans.* **81**E (*J. Appl. Mech.*), 4, 681–682 (Brief Notes), Dec. 1959.

3427. Maier, K., Glass-fiber sleeve-springs for high energy absorption, *Prod. Engng.* **30,** 33, 60–63, Aug. 1959.

Fastening and Joining Methods

(See Rev. 3399)

Rheology

(See also Revs. 3300, 3301)

3428. Kotaka, T., Kurata, M., and Tamura M., Normal stress effect in polymer solutions, *J. Appl. Phys.* **30**, 11, 1705–1712, Nov. 1959.

Generally, normal stresses are generated in addition to the shear stress in a viscoelastic flow system. In order to study the rheological behavior of the flow system, it is thus necessary to know the shear-stress component, σ_{12}, and the normal-stress components, $\sigma_{11} - \sigma_{33}$ and $\sigma_{22} - \sigma_{33}$. Authors describe the principles for determining the normal-stress components. By using a rheogoniometer (parallel plate type), authors determine the normal stresses for these polymeric solutions: polystyrene (a flexible chain type) in decaline, methylcellulose (a rigid chain type) in water, and sodium carboxymethylcellulose (a polyelectrolyze type) in water. The range of shear rates in these experiments was about 1.0 to 100. The normal stresses are plotted against shear rates; along with these curves the flow curves (shear stress versus shear rate) of the samples are shown. Authors found this correlation: the steeper the slope of the normal-stress curve, the less the non-Newtonian tendency.

Authors also outline the cross-elasticity theory, which correlates the normal stresses and the shear stress with the "recoverable shear." By analyzing the results, they conclude that polystyrene solutions are Hookean in shear, while the solutions of cellulose derivatives are non-Hookean.

H. Eyring and T. Rae, USA

3429. Coleman, B. D., and Noll, W., On certain steady flows of general fluids, *Arch. Rational Mech. Anal.* **3**, 4, 289–303, Aug. 1959.

Authors consider a *general fluid*, according to definition given in a previous paper [AMR **12** (1959), Rev. 5062; *Arch. Rational Mech. Anal.* **2**, 3, 197–226, 1958], and show that certain steady flow problems can be solved assuming only the definition of general fluid and its incompressibility. The solutions are expressed in terms of three unspecified real functions of one variable, called *material functions* by authors, which depend only on the material, not on the particular flow. Simple shearing flow, flow through a channel, Poiseuille flow and Cuette flow are considered by authors.

G. Sestini, Italy

3430. Hocking, L. M., A doublet technique for solving Oseen's equations of axisymmetric flow, *Mathematika* **5**, 10, 134–140, Dec. 1958.

Author extends the method of solving Oseen's equation used by L. Bairstow, B. M. Cave and E. D. Lang [*Phil. Trans. Roy. Soc.* (*A*) **223**, p. 383, 1923] for the flow of a viscous fluid past a cylinder to the problem of the axisymmetric flow in general. It is the characteristic feature of this method that a so-called "doublet solution" is constructed from two simple parts so that no flow of fluid out of the singularity of this solution exists. The flow itself then may be written by an integral over such doublet solutions the singularities of which are distributed on the surface of the axisymmetric rigid body placed in the stream. For the determination of the density of this distribution an integral equation is derived. The question of uniqueness is discussed. Finally, the particular case of a flow past a sphere at low Reynolds numbers is treated by this method in first approximation.

F. Engelmann, Germany

3431. Tyabin, N. V., and Vinvgradov, G. V., The theory of flow of plastic dispersions (in Russian), *Kolloidn. Zh.* **19**, 3, 352–360, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9922.

The curves of shear stress against rate of slip for rheological fluids, obtained by a rotary or capillary viscometer, are approximated by rectilinear segments. Substitution of a broken line for the real curve enables the flow of the actual fluid to be regarded as a flow of a series of Newton-Bingham fluids, and to apply the corresponding equations of motion. The derivation is given of the equation of flow of a rheological fluid through a circular pipe, applying the above-mentioned approximation.

A. I. Golubev
Courtesy Referativnyi Zhurnal, USSR

Hydraulics

(See also Revs. 3239, 3529, 3735, 3745, 3748, 3768)

Book—3432. Vallentine, H. R., Applied hydrodynamics, London, Butterworths Scientific Publications, 1959, viii + 272 pp. $10.

Author combines classical approach to hydrodynamics from basic principles with practical examples. Chapter 1 is devoted to flow in ideal fluid (two- and three-dimensional); continuity equations, Euler and Bernoulli equations are demonstrated. Chapter 2 characterizes real flow, introducing viscosity and turbulence. Theory of boundary layers is developed. Three approximate methods of determining flow patterns are developed in Chapter 3: the graphical, the numerical methods and the experimental analogy (membrane analogy, electrical analogy, viscous flow analogy). These three chapters are suitable for undergraduates in engineering sciences.

Chapters 4 to 7 are for advanced students and mathematicians. The general stream and potential functions (mentioned in Chapter 1) are developed in Chapter 4. Chapters 5 and 6 are on conformal transformation. Three-dimensional irrotational flow is dealt with in Chapter 7, with the Green, Stokes, Cauchy and Blasius theorems developed in an appendix.

The treatise as a whole is a highly commendable textbook representative of modern teaching methods at undergraduate and graduate levels.

C. Jaeger, England

3433. Gerashtchenko, O. A., and Nazarchuk, M. M., The influence of wettability of a surface on the solution of hydrodynamic problems (in Russian), *Zh. Tekh. Fiz.* **27**, 12, 2797–2798, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9825.

An attempt is made to explain the nature of the phenomenon of "sticking" of a viscous liquid to an unwettable contact surface. The frictional force developed in the presence of slip should follow the ordinary laws of dry friction. It can be shown by simple calculations that if the pressure is nearly atmospheric, the flow, e.g. of water, should in such case proceed with exaggeratedly large velocity gradients. In practice, the phenomenon of slip could only take place in the presence of highly reduced, static pressures.

V. P. Shidlooskii
Courtesy Referativnyi Zhurnal, USSR

3434. Yevdjevich, V. M., Computation of the outflow from a breached dam, Nat. Bur. Stands. Rep. 6473, 82 pp., July 1959.

Report of investigation of a complex problem of the flood wave in a valley after an accidental or deliberate dam breach. Several cases are discussed, based on the size and type of openings and on the time of release of stored water. It is obvious that solution can be only approximate, even with many simplifying assumptions. A case of the Savage River reservoir is demonstrated as a practical case. Two valuable discussions are joined in appendices:

(1) Analytical integration of the differential equation of water storage; the storage and the rating curves are taken in exponential form, and diagrams and tables are given for different powers.
(2) Effect of the sudden water release on the reservoir free outflow hydrograph: effect of the steep negative wave, effect of the resistance, procedure of computation of the discharge diagram, maximum outflow discharge. A thorough and lucid presentation makes this preliminary publication of great significance for hydraulic engineers and hydrologists.

S. Kolupaila, USA

3435. Ghosal, A., On the continuous analogue of Holdaway's problem for the finite dam, *Austral. J. Appl. Sci.* **10**, 4, 365-370, Dec. 1959.

Author obtains the solution for the continuous analog of a problem solved previously by Moran [*Austral. J. Appl. Sci.* **6**, 117-130, 1955] for the discrete case.

B. Epstein, USA

3436. Popov, V. N., The velocity and depth of flow of a current in the upper pond of a weir (in Russian), *Trudi Kievsk. Avtomob.-dor. In-ta* no. 3, 134-144, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9869.

A method of calculation is described for the case of an unsubmerged weir with a relatively long sill, approximately valid for cross sections of any regular geometric form and any straight slope of the bottom. The solution of the problem is based on application of the equation of quantity of motion. A coefficient is introduced, representing the relationship between the resultants of the actual excess head over the side of the weir and of the head in a hydrostatic distribution. This coefficient is a criterion of the nature of the jet flow over the weir (free fall, with air access under the jet, or otherwise in the presence of a vacuum). Author's experiments confirm M. D. Chernoussov's assumption that when the slope of the apron is subcritical the depth over the side of the weir is likewise subcritical. Consequently, the rate of flow is greater than that corresponding to the critical depth. This velocity is 1.4-1.7 times greater than the critical speed, depending on the conditions of flow and the form of cross section of the channel (rectangular, trapezoidal, or triangular). The subject is treated with insufficient rigor.

B. I. Bek-Marmarchev
Courtesy Referativnyi Zhurnal, USSR

3437. Kasugaya, N., On the accuracies of the author's formulas for calculating the discharge rate in a pipe and on the modification of the ordinary formula (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **65**, 16-24, Nov. 1959.

Author examines remainders appearing in his formulas, which he derived in his latest paper by mechanical quadrature, for calculating the discharge rate in a pipe, and obtains two new formulas by modifying ordinary formula. In one of the formulas, coefficients are so modified as to minimize the remainder for the ordinary positions of measuring points. In the other of them, the positions of measuring points are so modified as to minimize the remainder, and to let the coefficients remain equally weighted. Application of the present formulas to the velocity distribution in a pipe and the author's experiments verify the excellence of their accuracies.

From author's summary
Courtesy of the Editorial Committee,
Japan Society of Civil Engineers

3438. Petukhov, B. S., and Muchnik, G. F., The problem of hydraulic resistance in the turbulent, anisothermal flow of a liquid in a pipe (in Russian), *Zh. Tekh. Fiz.* **27**, 5, 1095-1099, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9840.

From an analysis of measured results, authors derive the following generalized formula for the coefficient of resistance (drag coefficient) of a turbulent, nonisothermal flow of an incompressible liquid in a pipeline

$$\xi = \frac{1}{(1.82 \log R_{\mathrm{liq}} - 1.64)^2} \left(\frac{\mu_w}{\mu_{\mathrm{liq}}}\right)^n,$$

in which $n = 0.14$ when the liquid is heated, and $n = 0.28\, P_{\mathrm{liq}}^{-1/4}$ when it is being cooled. The subscript "liq" distinguishes the parameters at the mean temperature of the liquid; "w" at the temperature of the wall. The equation is valid for long pipes at Reynolds numbers of $3.3 \times 10^3 < R_{\mathrm{liq}} < 2.5 \times 10^5$, and Prandtl numbers of $1.3 < P_{\mathrm{liq}} < 178$; and $0.3 < \mu_w/\mu_{\mathrm{liq}} < 38$. For noncircular pipe sections, it is suggested that R_{liq} be calculated from the equivalent diameter.

K. I. Artamonov
Courtesy Referativnyi Zhurnal, USSR

3439. Kutateladze, S. S., Analysis of the heat losses and hydraulic resistances in the flow of liquid metals along pipes (in Russian), *Energomashinostroenie* no. 6, 5-8, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9972.

Results are communicated of experiments on the investigation of the frictional resistance (bismuth, lead-bismuth) and heat loss (lead-bismuth, sodium) flowing in cylindrical pipes. The experimental installations are described. The hydraulic resistance for the case of bismuth is determined only for the isothermal state; and for the binary, lead-bismuth alloy, also during heating (q = 0-800 $\times 10^3$ kcal/m^2/hr). The experiments confirmed the presence in all cases of a square-law relationship between resistance and flow velocity. Supplementary experiments have shown that analysis of the local resistances in a flow of liquid metal can be performed by the ordinary equations. The heat loss was investigated for the flow of liquid metals with values of the Peclet number between 100 and 11000, Reynolds number $R > 10^4$, Prandtl number σ, 0.005-0.035, heat flows up to 1.13×10^6 kcal/m^2/hr, l/d = 15-103, and d = 4-35 mm.

I. L. Mostinskii
Courtesy Referativnyi Zhurnal, USSR

3440. Chen Che-Pen, M., The difference between the head losses in a pipe with a circular cross section and those in a shallow open channel (in French), *Houille Blanche* **14**, 6, 820-826, Nov. 1959.

Experiments show that the velocity distribution near the walls of a smooth open channel is given by the same universal law as for pipes; therefore the differences in the resistance law should be explained through the differences in the velocity distributions in the central part of the flow. This distribution, for open channel flows, depends probably on many factors, but certainly the Froude number F has great importance. Elaborating the results of experiments performed in laboratory channels at Saint Cyr and Chatou, author derives an expression of the difference between the values of $1/\sqrt{2}$ for open channels and for pipes as a quadratic function of F. For very large and shallow flows and low Froude numbers this function comes to $3.2\,F - 2.92$. Experiments have concerned Reynolds numbers between 1.5×10^5 and 7.5×10^5.

D. Citrini, Italy

Book—3441. Sokolovskii, D. L., River runoff, [Rechnoi stok] 2nd ed., Leningrad, Gidrometeoizdat, 1959, 527 pp. $1.25.

This is a second, revised edition of one of the best Russian books on continental hydrology. Having reviewed the first edition [AMR **7** (1954), Rev. 3933], reviewer was very pleased to compare it with the present edition and to see that his constructive remarks had been accepted by the author. Contradictory opinions and nonscientific remarks, enforced by the publisher 7 years ago, are eliminated in new edition, and thus the book has gained very much. A valuable list of references now contains most significant foreign sources, although with some typographical errors.

The book contains chapters on water balance in river and lake basins, average runoff, fluctuations of annual runoff, monthly distribution, minimum runoff, maximum flow, sediment runoff. Tables of probability and distribution conclude the text. It would be de-

sirable to publish an English translation of this book, which should be very interesting for our hydrologists.

S. Kolupaila, USA

3442. Bogardi, J., Hydraulic similarity of river models with movable bed (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24**, 3/4, 417-446, 1959.

A method for the computation of river models with movable bed was developed in 1955 on basis of the channel stability factor introduced earlier by the author. The comprehensive method developed by H. A. Einstein and Ning Chien is described in detail and with regard for results of recent theoretical investigations certain modifications and alterations are suggested.

According to the proposed method, two scale ratios may be selected freely and 8 condition equations are introduced for the computation of the remaining eight scale ratios. Seven of these criteria are identical with the corresponding ones in the Einstein method.

In conclusion the computation of the scale ratios for a model reflecting sediment transport conditions in a reach in the Tisza River near Szolnok is illustrated. Results obtained are compared to those computed according to the method of Einstein. Improved accuracy and a more refined technique result from the application of the method relying upon the new parameter that has been suggested.

From author's summary

3443. Takase, N., and Shiga, T., On some examples of run-off analysis for river basins with only a few available hydrological data (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **64**, 28-38, Sept. 1959.

In Japan, many researches have been done on the analysis of the run-off phenomena for river basins for which much hydrological data are available, in order to contribute to the rationalization of river planning, but the run-off analysis for river basins for which only limited hydrological data are available is so difficult that satisfactory results have not been obtained so far.

In this paper, authors analyze the run-off phenomena for river basins for which little data are available, utilizing the results of recent hydrological researches.

From authors' summary

Courtesy of the Editorial Committee, Japan Society of Civil Engineers

3444. Kinoshita, T., On the motion of the flood-flow running down through the river, *Trans. Japan Soc. Civ. Engrs.* **63**, 57-65, July 1959; **64**, 101-111, Sept. 1959.

Combining the equations of motion of fluid with the equation of continuity, author solves numerically differential equations of flood-flow, which is one kind of unsteady flow. The flood-flow under consideration is a nonlinear problem with finite amplitude. Some characteristics are deduced by numerical computation. His method is justified by comparing the calculated results with observed floods.

From author's summary

Courtesy of the Editorial Committee, Japan Society of Civil Engineers

Book—3445. Velikanov, M. A., Channel development, theoretical principles [Ruslovoi protsess (osnovy teorii)], Moscow, Gosudarstvennoe Izdatel'stvo Fiziko-Matematichoskoi Literatury, 1958, 395 pp. $2,

Book is a survey of knowledge of river dynamics and its channel development. Contents include: Erosion; Channel forms and currents; Variability of channel; Mutual interaction between stream and bottom; Turbulence, a main factor of channel development; Statistical analysis of turbulent pulsation and bottom sedimentation; Balance of energy; Structure of turbulence; Secondary circulation; Mechanical characteristics of sediments; Stream action on the shifting bottom, dunes; Silt pulsation; Suspension and transportation energy; Solid discharge; Silt distribution along a vertical; Silting computation; River regulation principles.

Book represents present status of river hydrology in Russia and should be of great interest to our engineers working on river and sedimentation problems.

S. Kolupaila, USA

Book—3446. Blizniak, E. V., editor, Channel developments [Ruslovyie protsessy], Moscow, Izdatelstvo Akademii Nauk SSSR, 1958, 394 pp. $4.

This collection of contributions by 33 authors deals with the important problem of interaction between the stream and movable bottom. Many papers discuss model investigations of natural channels. I. V. Egiazarov is one of the authors on models. Several articles deal with silting of storage reservoirs. Others describe investigations of sediments and of secondary currents. I. K. Nikitin demonstrates his instrument for investigation of stream pulsation: a jet of copper sulphate leaves a spot on an iron grid immersed in water in its path for 1 minute. Many articles are of great scientific interest and deserve separate reviews.

S. Kolupaila, USA

Book—3447. Rozovskii, I. L., Water movement in a curved open channel [Dvizheniie vody na povorote otkrytogo rusla], Kiev, Akademiia Nauk Ukrainskoi SSR, 1957, 188 pp. $1.50.

First part contains theoretical investigation of water flow through a channel bend, as a two-dimensional problem. Second part studies velocity distribution along and across a channel, three-dimensionally. In the third part experiments, both in laboratory and in natural conditions, are described. Theoretical part is based on a famous work of Professor A. Ia. Milovich.

S. Kolupaila, USA

3448. Araki, M., Hydraulic behavior of radially open channel flow (in Japanese), *Trans. Japan Soc. Civ. Engrs.* **63**, 48-56, July 1959.

An equation based on the principle of conservation of energy is derived in this paper. The hydraulic behavior of the flow is described in detail. Analyses show that surface profiles of the flow take various and systematic changes according to the difference of the bottom slope.

From author's summary

Courtesy of the Editorial Committee, Japan Society of Civil Engineers

3449. Metzler, D. E., and Rouse, H., Hydraulics of box culverts, State Univ. Iowa, Studies in Engng. Bull. 38, 34 pp., 1959.

3450. Kalashnikov, P. M., The hydraulic analysis of triangular ditches according to the characteristics of their free cross sections (in Russian), *Sb. Nauchn. Trudi, Belorussk. Lesotekhn. In-ta* no. 10, 249-258, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9855.

Author applies the method of I. I. Agrosskin for the calculation of trapezoidal channels by the characteristics of their free cross sections [*Gidrotekhnika i melioratsiya* no. 9, 14-32, 1953] to the hydraulic analysis of ditches of triangular cross section with slopes of identical and different steepness. Auxiliary curve charts and a specimen calculation are given.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR

3451. Yevdjevich, V. M., Effect of sudden water release on the reservoir free outflow hydrograph, *J. Res., Nat. Bur. Stands.* **63B** (*Mathematics and Mathematical Physics*), 2, 117-129, Oct./Dec. 1959.

A general procedure is developed for determining the outflow hydrograph for sudden releases from reservoirs when there is no tailwater effect. Both the effect of a steep negative wave moving back up reservoir and the effect of flow assistance are analyzed through use of a fictitious inflow hydrograph. Maximum outflow was found for same reservoir level but already accelerated water.

J. C. Geyer, USA

3452. Advani, R. M., Computation of backwater curves in open channels, *J. Instn. Engrs., India* **40**, 2 (part 1), 35-57, Oct. 1959.

Author discusses several methods for the computation of backwater curves for artificial and natural channels. The direct integration methods of Bakhmeteff and Von Seggern, designed for channels of all shapes, have broad application for artificial prismatic channels and afford a more accurate computation procedure than the equivalent profile method as developed by Bresse, Rühlmann, Tolkmitt and Kozeny. Owing to the variation in slope and rugosity in natural nonprismatic channels, the direct-step methods and especially the graphical method by Escoffier-Raytchine-Chatelier are found to be the best in several applications.

G. A. Heyndrickx, Belgium

3453. Ellison, T. H., and Turner, J. S., Turbulent entrainment in stratified flows, *J. Fluid Mech.* **6**, 3, 423–448, Oct. 1959.

Paper deals with a phenomenon which occurs often in nature: a thin layer of fluid which may be either lighter or heavier than its surroundings flows up under a sloping roof or down a sloping floor (as an example, katabatic winds in the atmosphere, fresh water currents in estuaries, density currents in reservoirs, methane flow in galleries). Plumes and jets of this kind are free turbulent flows, in which surrounding fluid is entrained; the theory presented in the paper assumes that the entrainment is proportional to the velocity of the layer multiplied by an empirical entrainment constant E, which is a function of the Richardson number Ri of the layer (i.e. the inverse square of the internal Froude number). The theory predicts that in most practical cases the layer will rapidly attain an equilibrium state in which Ri does not vary with distance downstream.

The theory is supported by previous experiments on inclined plumes by Georgeson (1942), and by two series carried out by authors at the Cavendish Laboratory and at the University of Manchester, the first concerning the phenomena of surface jets and the second those of inclined plumes. The experiments are in agreement, showing that E falls off rapidly as Ri increases and is negligible when Ri is more than about 0.8. The effects of Reynolds number seem to be of moderate importance. The results enable the prediction of mean velocity and concentration, and an estimate is also given of the effect of motion of the ambient fluid.

Reviewer is of the opinion that remarkable progress in researches on density currents could be made by a comprehensive comparison of field data with the theoretical approach followed by authors.

A. Ghetti, Italy

Book—3454. Angelin, S., The hydraulic laboratory at Alvkarleby, Stockholm, Kungl. Vattenfallsstyrelsen (Blue-white series no. 23), 1959, 20 pp.

First permanent laboratory, built at Älvkarleby on a bank of the Dalälven River in 1943, has been enlarged several times. A new reinforced-concrete building is 175 ft long and 150 ft wide, and is well-equipped. Five pumps supply 35 cfs water to the constant-head flume. The floor is of tightly packed gravel and sand. As many as 30 models can be used simultaneously. Traveling crane is used for model transportation and for photo camera. Testing program is extensive, dealing mostly with local problems, e.g., power station intakes, cooling water intakes, stilling basins, gates for log-floating spillways, timber floating problems, turbine tests. Several examples are presented.

Data concerning costs of the laboratory and its economic profit are added. Opinion of author on model scales is very important: conclusions drawn from tests on a model built to very small scale can be worse than without any test.

This publication represents high quality of hydraulic research done in Sweden, and is excellently illustrated.

S. Kolupaila, USA

3455. Middleton, Helen K., edited by, Hydraulic research in the United States, Nat. Bur. Stands. Misc. Publ. 227, 188 pp., Oct. 1959.

Incompressible Flow

(See also Revs. 3225, 3429, 3430, 3432, 3438, 3444, 3451, 3499, 3501, 3503, 3510, 3517, 3518, 3521, 3532, 3534, 3538, 3546, 3586, 3589, 3642, 3644, 3645, 3766, 3767, 3768)

3456. Kawaguti, M., The flow of a viscous fluid past a triangular cylinder, *J. Phys. Soc. Japan* **14**, 10, 1425–1431, Oct. 1959.

Total drag coefficient of equilateral triangular cylinder at small Reynolds numbers is obtained by solving Oseen's equations of motion by Imai's method which gives drag coefficient as a series in the Reynolds number. Expression is also obtained for frictional drag coefficient as a series in the Reynolds number. Expression for total drag coefficient is sufficiently accurate up to a Reynolds number of about 5 and that for the frictional drag coefficient up to a Reynolds number of about 2. Ratio of frictional to total drag coefficient depends on Reynolds number. To the order of the approximation the drag of the equilateral triangle does not change when triangle is rotated through 180 degrees. Drag of triangular cylinder at high Reynolds numbers is estimated by Imai's new theory in which drag coefficient at high Reynolds numbers depends on drag coefficient calculated by Kirchoff's free-streamline theory, the Reynolds number to the minus one half power, and a factor that depends only on the shape of the obstacle. These drag coefficients are compared with experimental results.

N. Tetervin, USA

3457. Finn, R., On steady-state solutions of the Navier-Stokes partial differential equations (in English), *Arch. Rational Mech. Anal.* **3**, 5, 381–396, Sept. 1959.

Integral equation forms are given for the velocity and pressure in the steady flow of a viscous, incompressible fluid past a finite number of smooth, bounded obstacles. If the Dirichlet integral of the velocity over the region outside some sphere is bounded, that velocity is shown to approach a constant away from the obstacles.

C. M. Ablow, USA

3458. Kaufmann, W., Extension of Thomson's law of circulation to viscous fluids (in German), *Z. Flugwiss.* **7**, 4, 103–106, Apr. 1959.

Paper deals with fundamental theorems of vortex flow in a viscous incompressible fluid. Well-known results [c.f. Goldstein: "Modern development in fluid dynamics," page 29; Von Mises: "Mathematical theory of compressible fluid flow," page 55] on constancy of vortex strength through a vortex tube and variation of vorticity in a viscous fluid are re-derived in simple and detailed fashion. Particular case of a two-dimensional isolated vortex is discussed in terms of spreading of vorticity. Reviewer sees no new information in the paper, although the straightforward and clear exposition may be of interest to those unacquainted with the subject.

J. A. Laurmann, USA

3459. Gol'din, E. M., Hydrodynamic flow between separator disks (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 80–88, July 1957.

The flow of a single-phase incompressible fluid in a separator is analyzed. From the Navier-Stokes equation assuming laminar flow, general expressions are derived for the distributions of velocities and of pressure. The flow due to uniformly distributed sources along a circle and the flow due to a single source are analyzed in detail. The results of the analysis are not compared with experimental data.

N. Zuber, USA

3460. Menkes, J., On the stability of a shear layer, *J. Fluid Mech.* **6**, 4, 518–522, Nov. 1959.

Author considers inviscid shear layer having velocity distribution $U(y) = \tanh(y/d)$ and density distribution $\rho_0 \exp(-2Ly/d)$.

Neglecting gravity (Richardson number = 0) and assuming small disturbances, he obtains closed-form solution for neutral stability boundary and shows that disturbances having wavelengths less than the characteristic length d are stable in consequence of the density gradient. J. W. Miles, USA

3461. Garner, F. H., Jenson, V. G., and Keey, R. B., Flow pattern around spheres and the Reynolds analogy, *Trans. Inst. Chem. Engrs.* **37,** 4, 191–197, Aug. 1959.

This excellent review paper presents a well-balanced discussion of analytical and experimental considerations. The thorough literature survey from Stokes to 1959 includes over 50 references. Skin-friction drag, form drag, flow patterns, transition, momentum transfer, heat and mass transfer, etc. receive careful treatment. Special emphasis is placed on outlining the limitations of the Reynolds analogy. V. G. Szebehely, USA

3462. Gould, D. G., Approximate method for determining the potential flow about an arbitrary aerofoil section in two-dimensional finite stream with particular reference to large stream deflections, Nat. Res. Counc., Canada, LR 260, 36 pp., Aug. 1959.

The interference method of cascade theory is adapted to the approximate calculation of the potential flow about an airfoil section in a finite stream. It is shown that for stream deflections up to 90 degrees the difference between the cascade and finite stream flows about an airfoil is very small. Thus, for most practical calculations, the cascade-flow methods can be used for the approximate determination of the flow about arbitrary highly cambered sections giving large deflections.

W. Fiszdon, Poland

3463. Dean, W. R., and Hurst, J. M., Note on the motion of fluid in a curved pipe, *Mathematika* **6,** 77–85, June 1959.

Pipe is of circular or square section bent in form of a circular arc with radius large compared with pipe diameter. Secondary circulation, which, away from walls, is mainly outward from center of curvature, is replaced by uniform flow in that direction, and equation for flux along pipe is then solved. Equation shows that the secondary flow reduces the flux for a given pressure drop along the pipe, and that the maximum velocity is moved outward from pipe center. But the secondary flow is not related to the primary, and paper lacks physical discussion; it is not obvious whether some of the conclusions refer to real fluids or are consequences of assumptions and approximations peculiar to the solution obtained. Since motion is assumed invariant along pipe, solutions cannot be applied to ordinary pipe bends with moderate or large flow through them. R. S. Scorer, England

3464. Ranz, W. E., Some experiments on the dynamics of liquid films, *J. Appl. Phys.* **30,** 12, 1950–1955, Dec. 1959.

Two liquid film phenomena are investigated: (a) a soap film formed inside a circular ring is ruptured at its center, the rupture spreading in a circular form toward the anchored edges, and (b) a circular liquid sheet is formed by two equal-velocity water jets impinging against one another. The two phenomena are dynamically inverse to each other. For phenomenon (a) it is found on theoretical grounds (Rayleigh) that the ruptured edge moves outward at a speed constant with time and position; this is confirmed by experiment. Soap film thickness is measured by reflected color, light absorption, and static surface contour under the effect of gravity; it is found that thickness of film is not constant, and that it has an uneven surface. Methods of rupturing the film are described: by a sharp needle, by absorbent points, and by electric spark; the last method was found the most reliable provided the spark was continued long enough. Film-edge velocity was measured by double-image photographs, and also by repeated exposures with a Fastax camera. Results show that the ruptured film rolls up without thickening of the yet unconsumed film because the velocity of elastic wave is considerably less than the velocity of the free edge.

For phenomenon (b) the energy balance equation is stated from which the film thickness at a given radius is calculated. With consideration of mass balance and a momentum balance the velocity at the edge and the thickness of the film entering the edge are calculated; results are not in good agreement with experimental values. Author discusses nonsymmetrical films produced by jets impinging at a sufficient angle between the jets to give a spray sheet in one direction only. He compares phenomenon (b) to spraying from rotating disk.

This concise paper clarifies some of the basic factors in spray formation and fundamental equations related to it.

K. J. DeJuhasz, USA

3465. Alekseevskii, V. P., On a certain problem in the theory of jets, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 6, 1192–1201, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Flow of two opposed, incompressible impinging jets in an infinitely long, constant-area channel is considered. The primary jet completely fills the channel and the secondary jet, centered about the channel axis, only partially. In primary jet fixed coordinates, the problem represents constant jet "drilling" of an encased fluid.

For a steady solution of equal density jets in the plane case, a solution is found in "parametrical form" by use of complex variables. The auxiliary equation results from comparison of a Schwarz-Christoffel transformation from the complex potential plane with a similar transformation from an intermediate plane of the logarithm of the reciprocal complex conjugate velocity. For an infinite primary jet, identity with Birkhoff's results is noted.

Formulas for the penetration speed, depth and width which are extended to jets of different density and to the axisymmetrical case follow from a momentum balance.

D. E. Ordway, USA

3466. Blair, A., Metropolis, N., von Neumann, J., Taub, A. H., and Tsingou, M., A study of a numerical solution to a two-dimensional hydrodynamical problem, *Math. Tables Aids Comput.* **13,** 67, 145–184, July 1959.

Authors present a detailed discussion of the numerical solution, on the Maniac I computer, of the partial differential equations describing the two-dimensional motion of two incompressible fluids under the influence of gravity and hydrodynamical forces. The position of the fluid interface is given at $t = 0$ and the subsequent interface positions and velocity distributions are determined. Difference equations are derived and the method of solution described. The solution presented is for a simple rectangular boundary. However, the formulation is general and could be applied to more complex situations. The paper includes the posthumous publication of J. von Neumann's original formulation of the problem and his discussion of a rapidly converging scheme for the solution of large linear equation systems. The latter is of broader application but requires a familiarity with the mathematics of numerical analysis. Reviewer believes that this paper will be of significant interest to those concerned with the numerical solution of two- and three-dimensional transient problems.

G. C. Wallick, USA

3467. Van Spiegel, E., Boundary value problems in lifting surface theory, Delft, Technische Hogeschool te Delft, 1959, 138 pp.

Paper gives an approximate solution of the steady and oscillating flow past a circular thin airfoil in an incompressible fluid. The solution consists of a Green's function superposition for the acceleration potential and a special solution with appropriate singularity at the leading edge. To satisfy the boundary condition on the normal velocity component, author solves an integral equation for doublet distribution by replacing it by an infinite array of

algebraic equations and breaking it off. Rapid convergence is illustrated in several examples. L. Trilling, USA

3468. Carstens, M. R., and Roller, J. E., Boundary-shear stress in unsteady turbulent pipe flow, *Proc. Amer. Soc. Civ. Engrs.*, **85**, HY 2 (*J. Hydr. Div.*), 67–81, Feb. 1959.

Paper deals with both a theoretical and experimental study of boundary shear stress in accelerated turbulent flow. Turbulent rather than laminar flow is studied owing to the historical dependence of the instantaneous velocity profile in laminar flow on the piezometric-pressure gradient which makes each case of unsteady laminar flow unique. In turbulent flow the strong lateral diffusion of turbulent eddies tends to eliminate the dependence of the velocity distribution upon the history of the motion, thus affording a greater degree of generalization of results.

Experimental results were not considered sufficiently precise to arrive at the conclusion that the history of turbulent flow in accelerated motion does not affect the instantaneous flow variables. However, the study does indicate that the present engineering practice of assuming the unsteady friction factor equal to that for steady flow, $f_u = f_s$, is acceptable.

C. E. Carver, Jr., USA

3469. Volkov, A. N., Vibrations of a cylindrical envelope in a flow of an ideal fluid (in Russian), *Sb. Trudl Mosk. Inzh-Stroit. In-ta* no. 27, 3–11, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9677.

Author investigates the transverse vibrations of a short cylindrical envelope in the three-dimensional potential flow of an ideal (perfect) fluid. The velocity potential of the flow in the envelope is determined and the pressure of the fluid on the envelope walls.

Using the resulting expression for pressure on the walls of the envelope, author integrates a system of differential equations describing the distortion state of an envelope on hinged end supports (according to V. Z. Vlasov) and determines the frequency of transverse vibration of the envelope for a particular case of zero flow velocity.

The results obtained make it possible to evaluate approximately the influence of an added mass of fluid on the frequency of vibrations of the envelope. In conclusion a case is examined in which the flow of the liquid is outside the envelope. In this instance also an approximate formula is obtained for the frequency of vibration. Yu. M. Guliev

Courtesy Referativnyi Zhurnal, USSR

3470. Hutarew, G., The flow and the pressure drop for off and modulating valves and cocks (in German), *Regelungstech.* **7**, 6, 193–196, June 1959.

The object of this contribution is to supply information for calculating the flow and the pressure drop in pipe lines, for off and modulating valves, etc., according to the latest developments in the science of dynamics. The calculations are supported by curves plotted from experimentally obtained data.

From author's summary

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 3225, 3432, 3500, 3502, 3512, 3525, 3536, 3548, 3549, 3550, 3552, 3560, 3584, 3631, 3681, 3691, 3705, 3707, 3720, 3741)

3471. Spreiter, J. R., Aerodynamics of wings and bodies at transonic speeds, *J. Aero/Space Sci.* **26**, 8, 465–486, 517, Aug. 1959.

Paper represents a very comprehensive summary and critical discussion of transonic flow theory and experimental evidence. After a brief introduction outlining some of the fundamental difficulties in developing the theory, the basic differential equations are presented and their properties discussed. The latter section includes the "Mach Number freeze" phenomenon for two-dimensional and axisymmetric flows. Next is a discussion of similarity rules for finite-span wings and bodies of revolution, followed by the transonic equivalence and area rules. The hodograph and successive approximation methods are next discussed; also the integral equation and local linearization methods. Closing section deals with wind-tunnel wall interference at a Mach number of unity. An extensive bibliography is included.

M. J. Thompson, USA

3472. Kulpin, B. V., The influence of the Reynolds number on the fundamental operational indices of a single-stage jet compressor (in Russian), *Trudl Kazansk. Aviats. In-ta* **37**, 72–84, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9751.

An experimental investigation into the influence of the Reynolds number R on the characteristics of a jet compressor (gas ejector) with transonic nozzles for the internal and external feed of high-pressure air.

Comparison between the ejectors was conducted with the following constant parameters: ratio of the flow cross sections of the active and passive air currents $\alpha = 0.0814$; critical value of the coefficient of ejection $K_* = 2.5$; the pressure gradient in the high-pressure gas nozzle was equal to three.

As a result of these investigations, author arrives at the following conclusions: (1) With increasing Reynolds number R' (defined by the flow parameters at the outlet from the mixing chamber) from 0.3×10^{-6} up to 0.9×10^{6} the compression ratio of the compressor increased from $\epsilon = 1.055$ to $\epsilon = 1.105$ with external high pressure air feed and from $\epsilon = 1.064$ to $\epsilon = 1.084$ with internal air feed. (2) With increasing Reynolds number R' from 0.37×10^{6} to 1.15×10^{6} the limiting coefficient of ejection increases by 20% in both systems of high pressure air. (3) With variation of the Reynolds number R'' of the active air stream 0.2×10^{6} up to 1.25×10^{6} the compression ratio and efficiency of the ejector substantially alter and reach a maximum in systems of air feed. (4) An increase in the number of high-pressure gas nozzles can be used for more effectively reducing the length of the mixing chamber. For example, in the system with external-pressure air feed, for an increase in the number of nozzles from 2 to 12 the required length of the mixing chamber is reduced from 4 to 1 diameter. (5) In the ejector system with internal-pressure air feed the maximum compression ratio and efficiency was achieved with five high-pressure nozzles and the most efficient length of mixing chamber equals 4.5 diameters. (6) Other conditions being equal, the gas ejector with external-pressure air feed has better characteristics than the ejector with internal feed.

Author's last deduction is not consistent with the results of other ejector investigations. Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR

3473. Lutz, O., and Riester, E., The design of two-stage hot water ejectors (in German), *Z. Flugwiss.* **7**, 12, 350–355, Dec. 1959.

Evading the established analysis of two-phase supersonic flow, authors use a grossly oversimplified representation of the process in water-driven ejectors to study economic optimization of two-stage design, by condensing the water vapor formed in first stage before entering into second stage. No experiments were made.

E. F. Lype, USA

3474. Fraser, R. P., Eisenklam, P., and Wilkie, D., Investigation of supersonic flow separation in nozzles, *J. Mech. Engng. Sci.* **1**, 3, 267–279, Dec. 1959.

3475. Goddard, V. P., McLaughlin, J. A., and Brown, F. N. M., Visual supersonic flow patterns by means of smoke lines, *J. Aero/Space Sci.* **26,** 11, 761–762 (Readers' Forum), Nov. 1959.

3476. Sauer, R., Supersonic flow around axisymmetric bodies with curved axis (in German), *Ing.-Arch.* **28,** 289–290, Mar. 1959.

3477. Katskova, O. N., and Shmyglevsky, Yu. D., The axially-symmetrical supersonic flow of freely expanding gas with a two-dimensional interface (in Russian), *Vycbisl. Matematika* no. 2, 45–89, 1957; *Ref. Zb. Mekb.* no. 9, 1958, Rev. 9624.

The axially-symmetrical supersonic laminar flow of freely expanding gas with a two-dimensional interface (acoustic plane) is calculated.

The problem is analyzed in a co-ordinate system z, χ, where z is constant along the streamlines, and χ is constant along the characteristics of the second family. In the vicinity of the interface the solution is sought in the form of a power series in χ. For the coefficients of this series a system of three simple differential equations is obtained; the system is reduced to an equation of the third order, the solution of which is tabulated. The remaining part of the flow is constructed by the method of characteristics. Tables are given for the parameters of this flow, calculated for four values of the specific heat $\chi(\chi = 1.14000, 1.33000, 1.40000, 1.66667)$. The tables show the values of the Mach numbers, the slope of speed curve, the Cartesian co-ordinates and pressure integrals at the point where the streamlines cross the characteristic curves of the second family. The tables can be used for constructing axially symmetrical jet engine nozzles in the presence of a discontinuity in the critical cross section.

P. P. Koriavov

Courtesy Referativnyi Zhurnal, USSR

3478. Zierep, J., Lift and drag of long circular wings in supersonic flow (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 83–88.

At the leading edge of a free annulus in oblique supersonic flow discontinuities occur in the derivatives of the potential. The discontinuities run along the Mach lines (through the leading edge) toward the axis and grow beyond all limits. At the annulus the singularity on the axis causes a singularity (integrable) of local lift and drag. The application of the linear methods of characteristics for estimating the total lift (total moment and total drag) is shown to be permissible. From author's summary

3479. Chapman, D. R., Kuehn, D. M. and Larson, H. K., Investigation of separated flows in supersonic and subsonic streams with emphasis on the effect of transition, NACA Rep. 1356, 40 pp., 1958.

3480. Van Dyke, M. D., The similarity rules for second-order subsonic and supersonic flow, NACA Rep. 1374, 8 pp., 1958.

See AMR **10**(1957), Rev. 2188.

3481. Sauer, R., Supersonic flow around wing-body combinations (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 230–231.

The sink-source method of Th. von Kármán for supersonic flow over bodies of revolution at zero or small incidence is generalized in order to make it applicable to indented bodies of revolution. In this generalized form it is used for calculating supersonic flows over wing-body combinations. From author's summary

3482. Hall, I. M., Rogers, E. W. E., and Davis, B. M., Miss, Experiments with inclined blunt-nosed bodies at $M_0 = 2.45$, Aero. Res. Counc. Lond. Rep. Mem. 3128, 28 pp., 1959.

The flows about flat-nosed and hemispherical-nosed bodies of revolution were studied at $M_0 = 2.45$ and at incidences up to 28 deg. Schlieren photographs were taken in the plane of symmetry and the vortex wake was studied by the vapor-screen technique.

The vortex wake tended to remain stable to higher incidences than had been found for pointed-nosed bodies. Instability was first observed at incidences of about 15 deg and was more pronounced in the wake of the flat-nosed body.

Surface-pressure measurements were made, and the results integrated to give the axial forces and the distributions of normal forces on the bodies. From authors' summary

3483. Van Hise, V., Investigation of variation in base pressure over the Reynolds number range in which wake transition occurs for two-dimensional bodies at Mach numbers from 1.95 to 2.92, NASA TN D-167, 44 pp., Nov. 1959.

An investigation has been made to determine the effect of Reynolds number upon two-dimensional base pressure throughout the Reynolds number range of wake transition. Base-pressure variation with Reynolds number was found to agree qualitatively with the theoretical predictions of Crocco and Lees throughout wake transition. Fineness-ratio effects upon base pressure were relatively large and agreed qualitatively with theory. Model-shape effects upon base pressure became significant for fineness ratios of about 3 but were negligible for fineness ratios of about 8. The wake-minimum-disturbance length varied greatly with Reynolds number. The point of convergence of the shocks originating downstream of the wake dead-air region was found to be a good indication of the minimum-disturbance length. The tests covered a Reynolds number range of approximately 5,000 to 6,000,000 and a Mach number range of 1.95 to 2.92.

From author's summary

3484. Love, E. S., Generalized-Newtonian theory, *J. Aero/-Space Sci.* **26,** 5, 314–315 (Readers' Forum), May 1959.

Author generalizes Lees's [AMR **10**(1957), Rev. 2601] modification of Newtonian theory for blunt-nose bodies to apply to pointed-nose bodies as well. The result is expressed by $c_p/c_{p_{max}} = \sin^2\delta/\sin^2\delta_{max}$, where δ is the local inclination of the body surface and the subscript "max" refers to the maximum local inclination and pressure coefficient. For blunt-nose bodies $\delta_{max} = 90°$ and the generalized theory reverts to Lees's blunt-nose modification with $c_{p_{max}}$ given by normal shock relations. Author shows, by comparison of Newtonian and generalized-Newtonian theory with exact solutions, the superiority of generalized-Newtonian theory. He also shows that both two-dimensional and axisymmetric shapes are correlated by this generalization. Results are presented in two figures that support author's generalization and indicate the independence of the correlation from variations in both the hypersonic similarity parameter $K = m(d/1)$ and the ratio of specific heats γ.

Reviewer believes this generalization should be of interest to those engaged in development of hypersonic hardware as well as theory. A. Kovitz, USA

3485. Julius, J. D., Experimental pressure distributions over blunt two- and three-dimensional bodies having similar cross sections at a Mach number of 4.95, NASA TN D-157, 13 pp., Sept. 1959.

Measurements of the pressure distribution about two- and three-dimensional bodies having flat, hemispherical, and oval leading edges (nose shapes) have been made at a Mach number of 4.95 and at Reynolds numbers per foot ranging from 15×10^6 to 75×10^6. The results are compared with modified Newtonian theory with and without any consideration of the centrifugal forces present in the flow field. From author's summary

3486. Willis, D. R., On the flow of gases under nearly free molecular conditions, AFOSR TN 58-1093 (Princeton Univ., Dept.

Aero. Engng. Rep. 442; ASTIA AD 207 594), 50 pp. + 33 fig., Dec. 1958.

Boltzmann's equation is transformed into an integral equation, and an iterative method of solving for the distribution function is proposed. This method is shown to give the correct solution for the problem of linearized Couette flow, in contrast to several other proposed methods which are also examined. If the iteration commences with the free molecular distribution function, it appears that one iteration is sufficient to give the distribution function for nearly free molecular conditions. The method of first collisions is shown to be an approximate method of calculating this iterate. It is valid when the free-stream Mach number is high and the body temperature is comparable to the free-stream stagnation temperature.

The method is applied to various geometries and results presented for the corrections to the free molecular macroscopic quantities at the body. There is found to be a marked effect of both body temperature and free-stream Mach number.

From author's summary by H. Mirels, USA

3487. Baradell, D. L., Experimental verification of boundary-layer corrections in hypersonic nozzles, *J. Aero/Space Sci.* **26,** 7, 454-455 (Readers' Forum), July 1959.

3488. Love, E. S., Prediction of inviscid induced pressures from round leading edge blunting at hypersonic speeds, *ARS J.* **29,** 10, 792-794 (Tech. Notes), Oct. 1959.

3489. Erkman, J. O., Explosively induced nonuniform oblique shocks, *Physics of Fluids* **1,** 6, 535-540, Nov./Dec. 1958.

Author presents a study of the magnitude of explosively induced shock waves in metals, the effects of the angle of the detonation wave, and the effects of changing explosive and specimen properties.

A solution, based on application of hydrodynamic theory, is presented for the case where flow is everywhere supersonic. This solution gives the interface location, shock location in the specimen and the pressure at any point in the specimen. In solving, an isentropic relation is assumed between the pressure and density, the form of the equation being given by

$$P = a\rho^k - b \qquad [1]$$

For the specimen, usually a metal, this equation is fitted to experimentally determined data relating P and ρ. In the case of the gas, P, ρ, and sound speed $(dP/d\rho)^{½}$ are ordinarily known at only one point—the Chapman-Jouget point. Thus, one constant remains undetermined when equation [1] is applied to the gas.

The basic conclusion is reached that the value of the exponent to be used in the equation of state for the explosive gas resulting from the detonation of explosives having a density of 1.67 g/cc is equal to approximately 11/9, and that this value holds over a wide range of pressure.

C. B. Matthews, USA

3490. Shapiro, A. H., Shock waves and dissipation in a resonance tube, *J. Aero/Space Sci.* **26,** 10, 684-685 (Readers' Forum), Oct. 1959.

3491. Voorhies, H. G., and Scott, F. R., Anomalous precursor signals in helium shocks, *Physics of Fluids* **2,** 5, 576-577 (Research Notes), Sept./Oct. 1959.

3492. Krook, M., Continuum equations in the dynamics of rarefied gases, *J. Fluid Mech.* **6,** 4, 523-541, Nov. 1959.

Author derives a procedure for transforming boundary-value problems in gasdynamics from microscopic formulation into approximate continuum formulation. The starting point is the kinetic equations involving the distribution function and expressing three fundamental properties of the gas: number density, velocity and kinetic temperature. Multiplying the kinetic equations by 1, v, $1/2\ mv^2$, and integrating over velocity space, gives five well-known continuum equations. The stress tensor and the heat-flux vector may be regarded as dependent state-variables expressible in terms of the basic state-variables or one may assign to them velocity moments of still higher order. Next the author discusses the distribution functions, moments, moment equations, reduction procedure and introduces modified Maxwellian function. This latter is a product of the normalized Maxwell distribution function and a polynomial in the components of the velocity. Derivation of some characteristic items follows: characteristic velocities and temperatures, approximating functions and collisional temperatures. The main chapter is devoted to interaction models: Maxwell-Boltzmann, Fokker-Planck, statistical, Bhatnagar, Gross and Krook and Krook. A case of a one-dimensional, time-independent problem is considered in detail. Moment equations are reduced to a determinate set by representing the distribution functions as sums of modified Maxwellian functions based on various characteristic temperatures and velocities. The boundary conditions are chosen in form of two parallel plates. Two characteristic ratios of the system are Knudsen number and temperature ratio of the plates. Formal dependence of velocity distribution on Knudsen number refers to five intervals of K: $\ll 1$, ~ 0.2, ~ 1, ~ 5, $\gg 1$. A discussion on the choice of basic state-variables and structure of shock waves closes the paper.

M. Z. v. Krzywoblocki, USA

3493. Pashchenko, N. T., Flow of highly rarefied gas past an oscillating surface, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 4, 760-765, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, New York).

The usual framework of free-molecular theory (accommodation coefficient α; fraction of diffusely reflected molecules ϵ) is used to derive general formulas for pressure p, shear stress τ, rate of energy transfer E, and the density ρ, in terms of instantaneous local velocity $\mathbf{u}$ of the moving surface and its unit normal $\mathbf{n}$. The involved geometrical calculations (using covariant differentiation) are illustrated for the case of a flat plate sliding at zero angle of attack in the x^1 direction and oscillating perpendicularly to itself in the x^3 direction. The resulting overpressure is proportional to that of the continuum "piston theory," for reasons discussed.

The general formulas are shown valid for "mildly concave" surfaces: the number n_β of molecules impinging on the surface for the second time is shown to be negligibly small if $\tan^2\beta \ll 1$ and $(\mathbf{u}\cdot\mathbf{n})^2 \ll c_0^2$ (where the path from any point of the surface can graze the surface again at the maximum angle β, and where c_0 is the most probable molecular speed in the undisturbed stream).

M. V. Morkovin, USA

3494. DeMarcus, W. C., Couette flow at intermediate pressures, Union Carbide Nuclear Co., Div. Union Carbide Corp., Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tenn., Atomic Energy Commission Res. & Develop. Rep. K-1402, 11 pp., Nov. 1958.

One of a series of papers by the same author on the kinetic theory of gas flow at low pressures. Author utilizes a frankly mean-free-path treatment, assuming that a molecule leaves each collision in a randomly selected direction, bearing the mean-flow momentum characterizing the vicinity of its last collision and discharging this momentum at the point of its next collision. Collisions with the walls result in completely diffuse (cosine law) scattering relative to a coordinate system fixed in the wall. Number density and mean free path are assumed independent of position. The probability that a molecule will travel a distance r between collisions is taken proportional to $\exp(-r/\lambda)$, with λ, the mean free path, taken independent of molecular speed.

An integral equation for the macroscopic flow velocity results from a momentum balancing calculation. The solution of the equation is given in another report by the author (referred to only

as K-1302). The only result given here (shear stress on the stationary wall) is no more than 7% different from that found from the Navier-Stokes equations with Maxwell's slip boundary condition. The 7% occurs in the free-molecule flow limit.

F. S. Sherman, USA

3495. **Koga, T., Integrated form of the Boltzmann equation and its application to gas dynamics,** *Physics of Fluids* **2**, 5, 580–582 (Research Notes), Sept./Oct. 1959.

3496. **Davenport, E. E., Kuhn, R. E., and Sherman, I. R., Static force tests of several annular jet configurations in proximity to smooth and irregular ground,** NASA TN D-168, 13 pp., Nov. 1959.

The present investigation was undertaken to determine the effects of changing the planform from circular to elliptical and the effects of irregularities in the ground on the thrust augmentation of a discontinuous annular jet in ground proximity at zero forward speed.

The results indicate that appreciable thrust augmentation can be obtained with a discontinuous annular jet but the augmentation decreases with increasing percentage of open area in the jet curtain. Thrust augmentation is obtained with elliptical planforms but this augmentation is less than that of a circular planform of the same circumference. Surface irregularities decrease the thrust augmentation with the jet very close to the ground.

From authors' summary

3497. **Ershin, Sh. A., and Sakipov, Z. B., A study of the initial section of a turbulent jet of compressed gas,** *Soviet Phys.-Tech. Phys.* **4**, 1, 43–50, July 1959. (Translation of *Zh. Tekh. Fiz., USSR* **29**, 1, 51–61, Jan. 1959 by American Institute of Physics, New York, N. Y.)

3498. **Bagdoev, A. G., The transmission of pressure into a compressible heterogeneous fluid** (in Russian), *Vestn. Mosk. In-ta, Ser. Matem., Mekhan., Astron., Fiz., Khimii* no. 2, 45–50, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9633.

Given N layers of a perfect, compressible fluid with different densities and transonic speeds occupying a semi-space. At the boundary of the semi-space a known pressure arises and is propagated in the manner stated. It is necessary to determine the fluid motion in the layers and particularly the pressure field. Author solves the problem in linear formulation for the case of axial symmetry, assuming the resulting motion to be potential in each layer. Completing the Laplace transformations of the required functions, he finds a solution for the problem in the form of a Fourier integral. For the particular case of a binary fluid layer he transforms the solution and finally arrives at a sum of terms in the original, the number of which increases with time and which appear as the result of wave reflection and refraction at the boundaries of the layers and on the free surface. Further simplifications are obtained for the case of binary layers of an incompressible fluid.

The second part concerns the solution of the analogous problem of the density and speed of sound continuously varying in depth. The equation obtained for pressure by linearization in Lagrange co-ordinates is also first solved for exponential variation of the density in depth and constant speed of sound in Laplace transformations, after which the result is converted back. This solution, in spite of being obtained in quadratics, is of a very cumbersome form and difficult to appreciate. Simplification is obtained in the case of an incompressible (but laminarly heterogeneous) fluid. In the case when the pressure propagating over the free surface is constant, the distribution of pressure along the axis of symmetry is obtained in elementary functions.

S. S. Grigorian
Courtesy Referativnyi Zhurnal, USSR

3499. **Shapiro, A. H., On the maximum attainable temperature in resonance tubes,** *J. Aero/Space Sci.* **27**, 1, 66–67 (Readers' Forum), Jan. 1960.

It had been previously suggested that the maximum temperature of the air in a resonance tube is limited by the condition that a continuous pressure wave entering the inlet barely steepens to a shock wave when it leaves the exit. An additional mechanism for inhibiting energy dissipation within the tube, namely, that a time-mean temperature gradient can prevent a wave from steepening, is analyzed and leads to an estimate of the maximum attainable temperature at the closed end.

D. C. Leigh, USA

Boundary Layer

(See also Revs. 3423, 3456, 3457, 3460, 3461, 3468, 3515, 3516, 3537, 3556, 3591, 3592, 3594, 3596, 3597, 3616, 3644, 3681, 3718, 3755)

3500. **General research in flight sciences (Jan. 1958–Jan. 1959), Fluid mechanics, Vol. I: Viscous flows,** Lockheed Aircr. Corp., Missiles and Space Div. TR-48381, ix + 217 pp., Jan. 1959.

This volume contains eight papers, most of which are devoted to experimental or very approximate theoretical studies of high-speed viscous flows. In particular, much attention is given to the calculation of heat-transfer rates at and near stagnation points of blunt bodies placed in high Mach number flows. It is shown, for example, that the injection of helium into the boundary layer at the forward stagnation point of a blunt body results in a considerable reduction in heat-transfer rate. Shock-tube experiments show that theory satisfactorily predicts heat-transfer rates provided the gas is not ionized.

A. R. Mitchell, Scotland

3501. **Head, M. R., An approximate method of calculating the laminar boundary layer in two-dimensional incompressible flow,** Aero. Res. Counc. Lond. Rep. Mem. 3123, 53 pp., 1959.

This valuable report makes use of the momentum and energy integral equations of the laminar incompressible boundary layer. It differs from other versions in the manner of choice of the doubly infinite family of velocity profiles, which are found numerically; all known profiles, from the extremes of high suction types to separation types, are included. Paper includes comparisons with most of the known exact solutions and the agreement is remarkable, even in regions where other methods often fail. More important still, the method produces accurate velocity profiles; it is probably true that this is the only approximate method accurate enough for stability calculations.

It is most unfortunate that the three main charts, on which the use of the method depends, are inferior to those in the original report in that the grid lines are gone, the curves are thicker and the quality of the paper is not nearly so good. Another nine charts, used for finding the velocity profiles, also have no grid lines and are half the original size.

J. C. Cooke, England

3502. **Reshotko, E., and Beckwith, I. E., Compressible laminar boundary layer over a yawed infinite cylinder with heat transfer and arbitrary Prandtl number,** NACA Rep. 1379, 49 pp., 1958.

See AMR **11**(1958), Rev. 216.

3503. **Wu, C.-S., Solution of the three-dimensional laminar boundary layer over the surface of a rotating cone,** AFOSR TN 58-301 (Princeton Univ., Dept. Aero. Engng. Rep. 415; ASTIA AD 154 211), 11 pp., Apr. 1958.

The analytical investigation of the motion of an incompressible viscous fluid induced by a spinning cone is considered. Similar solutions have been found from the steady-state boundary-layer equations. Part of the numerical results are similar to Karman

[*ZAMM* **1**, p. 233,1921] and Cochran [*Proc. Phil. Soc.* **30**, p. 365, 1934] solutions for infinite disk. The pressure distribution across the boundary layer is obtained by simple integration.

From author's summary by N. Z. Azer, Egypt

3504. Hall, G. W., Application of boundary layer theory to explain some nozzle and venturi flow peculiarities, Instn. Mech. Engrs., Prepr., 1959, 8 pp.

The discharge coefficient of a nozzle for incompressible flow is estimated by boundary-layer calculations on an equivalent constant-diameter tube. The discharge coefficient is taken as 1-2 (displacement thickness/radius). The displacement thickness is calculated for laminar flow, fully turbulent flow and transitional flow, using conventional formulas. In transitional flow it is assumed that the momentum thickness is continuous through transition so there is a decrease in displacement thickness. This enables the author to account qualitatively for humps in the calibration curve reported by some investigators in terms of transition at a Reynolds number of about 10^5. This is lower than would be expected in a favorable pressure gradient, but it is shown that in nozzles of conventional design the pressure gradient along the wall is adverse upstream of the throat even though the pressure gradient on the center line is favorable.

W. Squire, USA

3505. Hall, M. G., On three-dimensional boundary layers having similar solutions, *J. Aero/Space Sci.* **27**, 1, p. 80 (Readers' Forum), Jan. 1960.

3506. Uram, E. M., Skin-friction calculation for turbulent boundary layers in adverse pressure distributions, *J. Aero/Space Sci.* **27**, 1, 75-76 (Readers' Forum), Jan. 1960.

On the basis of experimental results obtained from boundary-layer measurements, an empirical formula is developed for calculating the local skin-friction coefficient when the momentum thickness is known.

E. Petersohn, Sweden

3507. Granville, P. S., The determination of the local skin friction and the thickness of turbulent boundary layers from the velocity similarity laws, David W. Taylor Mod. Basin Rep. 1340, 18 pp., Oct. 1959.

The applicability of pipe calibrations of Preston tubes to boundary layers is discussed on the basis of the logarithmic similarity law and the displacement effect of the tubes. A new logarithmic formula for the boundary-layer thickness of flat plates which is especially useful for high Reynolds numbers is also derived from the similarity laws.

From author's summary by C. E. Carver, Jr., USA

3508. Durgin, F. H., An experiment on the insulating properties of boundary layers, AFOSR TN 57-392 (Mass. Inst. Technol., Naval Supersonic Lab. TR 218; ASTIA AD 132 467), 140 pp., July 1959.

Boundary-layer flow on a cone at zero yaw in a Mach 3.5 stream was studied experimentally. An isothermal wall, which cooled the flow over upstream half of cone, was followed by an adiabatic wall. Temperature distributions along the adiabatic wall are compared with theoretical results for three laminar flow experiments at a Reynolds number of 1.18×10^6 per foot and for two turbulent flow experiments at a Reynolds number of 4.13×10^6 per foot. Laminar data agree well with theoretical results of Shoulberg et al [MIT, WTR 36, May 1952] who integrated numerically Lighthill's equation. Experimental points for turbulent boundary-layer flow lie between theoretical curve from Rubesin [NACA TN 2345] and that from Seban [M.S. Thesis, U. of Calif., 1951]. All previous theoretical results are shown to be reducible to a single formalism developed from a unified parametric analysis valid for both laminar and turbulent boundary layers.

As author mentions, the streamwise temperature derivative at the wall undergoes discontinuity at the change from isothermal to adiabatic conditions. Terms such as the second streamwise temperature derivative are neglected in boundary-layer analyses, but this derivative may be large in the present case. Evidently, such effects decay rapidly because laminar flow experiments agree well with theory near the interface between the isothermal and adiabatic walls.

A. Q. Eschenroeder, USA

3509. Clutter, D. W., and Smith, A. M. O., Analysis of further data on the effect of isolated roughness on boundary-layer transition in supersonic flow, *J. Aero/Space Sci.* **27**, 1, p. 70 (Readers' Forum), Jan. 1960.

Data from tests made by Van Driest and McCauley in JPL 12-in. and 20-in. supersonic wind tunnels [*J. Aero/Space Sci.* **27**, 4, 261-271, Apr. 1960] correlated with roughness Reynolds number as suggested previously by authors [AMR **13** (1960), Rev. 1311]. Data support correlation though authors suggest similar tests be made in other supersonic wind tunnels to determine effects of turbulence level.

W. F. Davis, USA

3510. Das, A., Influence of boundary layer fences on the aerodynamic characteristics of swept and delta wings (in German), *Z. Flugwiss.* **7**, 8, 227-242, Aug. 1959.

Paper presents experimental and analytical study of the effect of a class of boundary-layer fences on 45° swept wings of aspect ratio 4 to 6 and delta wings. Main effect on swept wings is to break up the vortex generated by boundary-layer cross flow; this gives a vortex shed at a well-defined position and a local lift loss. Effect on delta wings is negligible.

L. Trilling, USA

3511. Sandborn, V. A., Measurements of intermittency of turbulent motion in a boundary layer, *J. Fluid Mech.* **6**, 2, 221-240, Aug. 1959.

The "flatness factor" $\overline{u}/(\overline{u^2})^2$ which is a measure of the intermittency of turbulent flow has been measured with a hot-wire anemometer at different locations from near transition to near separation in a turbulent boundary layer with an adverse pressure gradient. Passing the hot-wire signal through a variable band pass filter it has been possible to study intermittent character of narrow bands of frequency over the whole turbulence spectrum.

From the measurement author concludes that upstream of separation region the flatness factor depends on wave number and longitudinal distance but not on distance from the wall. Near separation, flatness factor changes radically in distribution near the wall and is there no longer independent of distance from the wall.

Measurements refer to inner part of boundary layer and not to the intermittency encountered in the vicinity of the irregular outer boundary of the layer.

S. K. F. Karlsson, Sweden

3512. Fiszdon, W., and Mollo-Christensen, E., An experiment on oscillatory shock-wave boundary-layer interaction, *J. Aero/Space Sci.* **27**, 1, p. 71 (Readers' Forum), Jan. 1960.

Oscillations of shock-wave boundary-layer interaction flow were investigated at $M = 2$. A shock generated by two-dimensional variable-depth cavity interacted with boundary layer on a flat plate. The results indicate that there is a resonant frequency of shock-wave boundary-layer interaction.

J. Lukasiewicz, USA

3513. Rosner, D. E., Chemically frozen boundary layers with catalytic surface reaction, *J. Aero/Space Sci.* **26**, 5, 281-286, May 1959.

The reactant concentration along a solid surface is considered for an incompressible boundary-layer flow with a single reacting species. A Lighthill-type equation for the surface concentration is obtained but is not used. Instead, a first-order differential

equation, based on the same assumptions, is solved numerically for the special case of flow over a flat plate. The result is found to differ by about 7% from that of Chambré and Acrivos [*J. Appl. Phys.* **27**, 11, 1322–1328, Nov. 1956]. Author points out that application of Ambok's approximate method [*Sov. Phys.-Tech. Phys.* (Amer. Inst. Physics Translation), **2**, 7, 1979–1987, Sept. 1957] to the same problem yields a closed-form solution that is numerically almost identical to the power-series solution of Chambré and Acrivos. L. Mack, USA

Turbulence

(See also Revs. 3432, 3461, 3468, 3507, 3509, 3548, 3587, 3588, 3625, 3657, 3718, 3755, 3756, 3760)

3514. Tien, C. L., On the eddy diffusivities for momentum and heat, *Appl. Scient. Res.* (*A*) **8**, 5, 345–348, 1959.

Author derives expression for eddy diffusivities of heat and momentum in terms of turbulence intensity and Lagrangian scale of turbulence. Both diffusivities are shown to be equal.

Using data of Mickelson [NACA TN 3570, 1955] and Laufer [NACA Rep. 1053, 1951] a semiempirical relation is obtained giving eddy diffusivity as function of friction velocity, tube diameter, and distance from wall. Values of constants are given. No comparison is made with existing experimental values of eddy diffusivities and no comment is made about the fact that eddy diffusivity of heat and eddy diffusivity of momentum are shown experimentally to be unequal. J. G. Knudsen, USA

3515. Harrison, M., Pressure fluctuations on the wall adjacent to a turbulent boundary layer, David W. Taylor Mod. Basin Rep. 1260, 13 pp., Dec. 1958.

As one of the causes of noise in aircraft is the flexible wall-turbulent boundary layer interaction, author presents experimental investigations on the pressure fluctuations on the wall of a subsonic wind tunnel (the speed U_0 = 50 to 200 ft/sec). The measurements were made for a fully developed turbulent boundary layer with zero pressure gradient, with the aid of small flush-mounted microphones. The upper frequency limit was 2000 cps. For obtaining the spectral analysis, a Muirhead-Pametrada wave analyzer was used. It is shown that the frequency spectrum of $\overline{p}^2$ has the same aspect as that of the turbulent fluctuations of velocity, but does not decrease so rapidly for small frequencies. This is due perhaps to the intermittent character of the motion. The coefficient $k = \overline{p}^2/[(\rho/2)\,U_0^2]$ is of the 10^{-2} order. By measuring the longitudinal cross-spectral density, author points out that the convection velocity of the pressure fluctuation is of the 0.8 U_0 order. The curve of the longitudinal cross-spectral density versus ($fx/0.8\ U_0$), where f is the frequency and x is the distance between the two measurement points, indicates the longitudinal coherence of the pressure fluctuations.

S. Savulescu, Roumania

3516. Ellis, S. R. M., and Gay, B., The parallel flow of two fluid streams: interfacial shear and fluid-fluid interaction, *Trans. Inst. Chem. Engrs.* **37**, 4, 206–213, Aug. 1959.

This interesting article reviews the case of a turbulent gas flowing over a liquid layer and adds new information obtained with air and water. The gas velocity profile and shearing stress show that the liquid behaves as a rough wall. No information is available on the size of the liquid ripples, or the role of surface tension. It was also observed that the turbulent gas flow induces turbulent motion in the liquid. R. Betchov, USA

Aerodynamics

(See also Revs. 3240, 3274, 3456, 3458, 3462, 3471, 3478, 3481, 3484, 3486, 3492, 3509, 3512, 3534, 3539, 3546, 3549, 3558, 3563, 3598, 3606, 3646, 3647, 3656, 3658, 3768, 3770)

3517. Garner, H. C., and Bryer, D. W., Experimental study of surface flow and part-span vortex layers on a cropped arrowhead wing, Aero. Res. Counc. Lond. Rep. Mem. 3107, 48 pp., 1959.

Paper gives results of comprehensive wind-tunnel measurements and observations relating to a wing having 49.4° leading-edge sweepback. Emphasis is on high incidence conditions when separation at the leading edge leads to the formation of a vortex region over the more outboard regions of the upper surface. In addition to measurements of lift, drag, pitching moment and surface pressures, a detailed picture of the separated vortex flow is obtained by a variety of techniques and instruments, including surface oil patterns, acoustic probe, tuft grid, velocity and pressure probes.

Reynolds number and stream turbulence are shown to influence the formation of the separated vortex layer, and the aerodynamic loading is considered in relation to the estimated strength of an equivalent vortex. N. C. Lambourne, England

3518. Smith, J. H. B., A theory of the separated flow from the curved leading edge of a slender wing, Aero. Res. Counc. Lond. Rep. Mem. 3116, 18 pp., 1959.

Paper extends calculations of title problem, based on model suggested by Brown and Michael [AMR **9**(1956), Rev. 229], to nonconical wings. The extension requires a step-by-step process to locate shed vortices as they extend downstream. Results for vortex strength and location as well as lift and center-of-pressure are tabulated and graphed for three wing planforms at several angles of attack. It is shown that plotting the quotient of lift coefficient by the product of angle of attack and aspect ratio ($C_L/A\delta$) versus the quotient of angle of attack by aspect ratio (δ/A) collapses the results for the curved-leading-edge wings onto the delta wing results fairly well. No experimental results are given. F. B. Fuller, USA

3519. Sheppard, L. M., Improving the accuracy of pressure distributions in linearised supersonic wing theory, Australian Defense Scientific Service, Weapons Research Establishment TN HSA 45, 13 pp., Jan. 1959.

Simple methods of obtaining improved pressure distributions on three-dimensional supersonic wings are investigated starting from the first-order, or linearized, pressure distribution. A method based on the second-order theory of two-dimensional supersonic airfoils is recommended.

This method has been applied to a flat plate delta wing with "supersonic" edges and the modified pressure distribution shows good agreement with the exact theoretical pressure distribution. No comparisons with experimental results or calculations for wings with subsonic leading edges are presented.

From author's summary by M. Epstein, USA

3520. Fink, M. P., Static tests of an external-flow jet-augmented flap test bed with a turbojet engine, NASA TN D-124, 19 pp., Dec. 1959.

An exploratory investigation has been conducted on a static test setup representing an external-flow jet-augmented flap arrangement with a slotted flap and a turbojet engine. The investigation consisted of tests in the static condition to determine the turning efficiency of the flap with several slot entrance configurations for a range of slot-gap heights with various flattened tailpipes on the turbojet engine.

The results showed that the jet exhaust could be spread out to cover a reasonably wide section of the flap with a flat nozzle and that, with a properly selected ramp entrance and gap geometry, jet turning angles greater than the flap angle and turning efficiency values greater than 90 % could be attained. The engine exhaust temperatures in the vicinity of the flap were found to be somewhat lower than the tailpipe temperature.

From author's summary

3521. Roshko, A., Computation of the increment of maximum lift due to flaps, Douglas Aircr. Co. Rep. SM-23626, 9 pp., July 1959.

For family of thin airfoils having same nose but different after-body, conditions of stall at the nose are identical for all airfoils (stagnation point location and pressure distribution around the nose). Using this idea author calculated maximum lift coefficient of thin airfoil with leading or trailing edge flap from standpoint of thin-airfoil theory. Comparison between experimental and calculated value shows good agreement for leading edge flap of 15% chord and flap deflection up to 20°.

S. Otsuka, Japan

3522. Sheppard, L. M., and Moore, E. J., Estimation of the interference wave drag between separated components of a wing-body combination, Australian Defense Scientific Service, Weapons Research Establishment TN HSA 44, 33 pp., Jan. 1959.

Authors investigate the problem of calculating the interference wave drag between wing and forebody, wing and afterbody, or forebody and afterbody. In all cases, the interfering elements are supposed to be separated from each other longitudinally by a cylindrical section which contributes nothing to the wave drag. Discontinuities in slope are allowed outside the region of the transferred wing area distribution. The calculation of the drag is based on linearized slender-body theory. In this way, the problem is reduced to the calculation of the interference wave drag between two slender bodies separated from each other. A series expansion method is developed for the case when the centers of the two area distributions are separated from each other by a large distance. Detailed consideration is given to the case where the component area distributions can be approximated by quartic polynomials. Comparisons of the series expansion procedure with exact calculations indicate that a large number of terms of the series may be required to accurately determine magnitude of the interference wave drag. The accuracy of the series calculation is apparently a strong function of the ratio of the distance between the centers of the area distributions to the total length of the area distributions. Since, in many practical applications, the interference wave drag is a small fraction of the total drag, the series expansion technique may prove useful in making preliminary drag estimates.

M. Epstein, USA

3523. Mostovoi, A. C., A possible standardization of the degree of longitudinal stability of high-speed aircraft (in Russian), *Trudi Kuibishevsk. Aviats. In-ta* no. 3, 247-257, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9660.

To obtain a wide range of Mach numbers with a suitable degree of longitudinal stability for an aircraft allowing for overload and speed, it is suggested, in addition to the elevator, to use a stabilizer, automatically controlled by a special servomotor, according to the amount of excess loading, the Mach number and the flying height. The deflection characteristics of the stabilizer are determined by the known criteria of longitudinal stability and the maneuverability of the aircraft with the stabilizer locked.

A method is described for calculating the amount of deflection of the stabilizer necessary to obtain the desired degree of stability. Formulas are given for determining the stick force for the cases where the servomotor is incorporated in the usual two-way system of control. Singularities are indicated in the choice of the degree of stability for aircraft possessing equipment with this automatic stabilizer.

Iu. I. Sneshko

Courtesy Referativnyi Zhurnal, USSR

3524. DeRose, C. E., and Boissevain, A. G., An exploratory investigation in a ballistic range of the stability derivatives of a simple airplane configuration at low supersonic speeds, NASA TN D-139, 25 pp., Dec. 1959.

An exploratory investigation of the problems of obtaining stability derivatives of airplane-like models in a ballistic range was conducted. A simple body-wing-tail configuration having two planes or mirror symmetry was tested at Mach numbers of 1.2 to 1.4 and Reynolds numbers (based on wing chord) of 0.8 to 1.0 × 10^6. Results show that stability derivatives can be extracted only from those runs in which the rolling rate was negligibly small or zero; stability derivatives from these runs compared fairly well with existing theory.

From authors' summary

Vibration and Wave Motions in Fluids

(See also Revs. 3435, 3453, 3460, 3499, 3512, 3538, 3564, 3660, 3706, 3718, 3740, 3750, 3753, 3754, 3764, 3765, 3766, 3772)

3525. Powell, A., One-dimensional treatment of weak disturbances of a shockwave, Aero. Res. Counc. Lond. Curr. Pap. 441, 12 pp., 1959.

In a previous paper [Aero. Res. Counc., Lond., Curr. Pap. 194, 1954; AMR **10**(1957), Rev. 578] the author computed disturbances resulting from interaction of sound wave or weak temperature disturbance with shock [Burgers, J. M., *K. Neder. Akad. Wet.* **44**, 1946]. These results were in error and present paper provides corrected values of reflection and transmission coefficients for shocks in polytropic gas with Mach number from 1 to 5.

P. M. Stocker, England

3526. Tellep, D. M., The effect of vehicle deceleration on a melting surface, *J. Aero/Space Sci.* **26**, 8, 537-538 (Readers' Forum), Aug. 1959.

3527. Gaziev, E. G., Determination of the length of a hydraulic jump (in Russian), *Gidrotekh. Stroit.* **27**, 1, 46-48, Jan. 1958.

This article, published under the heading "Letters and response of lecturers" is in connection with G. G. Bogdanov's article [*Gidrotekh. Stroit.* no. 7, 51-53, July 1956] treating the same problem. It represents an attempt to determine theoretically the length of hydraulic jump. Using the momentum equation for pressure and inertial forces, the magnitude of momentum M is obtained. Further it assumes the rollers volume to be proportional to M, and its length to square root of M. The length of hydraulic jump obtained in this way is expressed in dimensionless form (w.r.t. the first conjugate depth). The expression contains an indeterminate coefficient, which can be evaluated only by experiments and, according to the author, it is a function of Froude number. This fact decreases to a great extent the value of this article, because according to the dimensional analysis the length of the jump is solely a function of the Froude number.

M. M. Boreli, Yugoslavia

3528. Brannower, G. G., An investigation into the drowning of a surface jump (in Latvian), *LatvPSR Zinatnu Akad. Vestis* no. 5, 131-146, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9867.

A relationship is suggested for the magnitude of the pressure head h_n under a jet descending from a sill, at the instant of sub-

mergence (drowning) of the surface jump. The relationship is derived by applying the law of quantity of motion to a volume bounded by the constricted cross section at the sill, the free surface, the cross section at the deflection point (point of descent) of the jet, and the interface between the transient jet and the weir. It is assumed that a hydrostatic law of pressure distribution applies in the cross sections at the sill and at the deflection point of the jet; the distance from the sill to the deflection point and the frictional forces at the boundary of the transient jet are determined experimentally. Finally, it is assumed that, at the instant of drowning, the jet becomes vertical in the deflection point. A relationship is further derived between the pressure under the jet h_0 and the depth in the lower pound (tail race) t_2, at the instant of submergence of the surface jump, which is also obtained by applying the law of quantity of motion. A chart is provided to simplify calculation by the resulting third-order equation.

T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR

3529. Mossakovskii, V. I., and Rvachev, V. L., On the problem of horizontal hydrodynamic impact of a sphere, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 6, 1217-1220, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A spherical bowl whose wetted surface has the equation $r^2 = x^2 + y^2 + z^2 = 1$ is immersed in an incompressible fluid that fills the half space $z \geqslant 0$. This sphere is suddenly given an impulsive velocity U_0. A solution for the potential function in the fluid in a closed form is developed and the values of the virtual mass coefficients for the sphere with fluid outside and fluid inside are determined. These agree closely with a previous series solution based upon spherical harmonic functions.

F. E. Reed, USA

3530. Franz, G. J., Splashes as sources of sound in liquids, *J. Acoust. Soc. Amer.* **31,** 8, 1080-1096, Aug. 1959.

The mechanisms of sound production by the splashes made by the gas-to-liquid entry of objects are discussed. The sound from the splash is considered to be associated with acoustic multipoles of all orders, the main ones being simple sources, dipoles, and quadrupoles. The orders of the multipoles that predominate during the various phases of the splash are estimated from the flow and boundary conditions. The sounds radiated into the water by the low-velocity entry of single water droplets, sprays of water droplets, and various other objects, such as spheres, cones, and wedges, have been measured and found to have the characteristics of acoustic dipoles. The extensive experimental data on the spectrum of the underwater sound from the splashes of droplets and sprays and the scaling laws for dipoles are used to estimate the spectrum levels of the underwater sound from the splashing of rain on the surface of a sea in terms of the rate of rainfall.

From author's summary by M. Greenspan, USA

3531. Ivanov, L. S., The distribution of momentum pressures in the impact of a liquid on the walls of an open, rectangular tank (in Russian), *Trudi Mosk. Tekh. In-ta Rybn. Prom-sti i Kh-va* no. 8, 229-234 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9822.

An ideal imcompressible liquid fills an open vessel (tank) of rectangular shape, and instantaneously acquires a horizontal velocity. The problem is two-dimensional. Using a solution found earlier by the author for the hydrodynamic problem [*Prikl. Mat. Mekh.* **17,** 4, 1953], the distribution of the impulse (momentum) pressure on the vertical wall (s), is found. When the ratio of the length of the tank l_1 to the height l_2, goes from zero to infinity, the position of the center of pressure on the vertical wall changes from 0.5 l_2 to 0.37 l_2.

M. I. Gurevich

Courtesy Referativnyi Zhurnal, USSR

Fluid Machinery

(See also Revs. 3348, 3472, 3768)

3532. Meyer, L., Singularity theory of cascades of airfoils (in German), ETH Mitt. Inst. Aero., Zurich, no. 26, 127 pp., 1959.

Study is based on the cascade theory for very small blade gaps by J. Ackeret [*Schweiz. Bauztg.* **120,** p. 120, 1942]. In this theory the profiles are produced by vortices and sources continuously distributed in both normal and tangential directions. The progress in present author's theory consists of the concentration of the singularities on the mean lines of the profiles, which are obtained beforehand by the simple Euler theory (congruent streamlines).

The starting point is a vector diagram and a chord-gap ratio of a cascade flow. Furthermore a distribution of the circulation and the profile thickness along the blade chord is assumed. The mean-line contour and the velocity distribution along the blade shape are obtained at zero incidence. Other inlet angles, when retaining the same profile shape, result by superposing the circulatory portion of flat plate cascade flow. It is further possible to design a profile with prescribed pressure distribution on the suction side of the blade using an iterative procedure.

Some examples of compressor cascades illustrate particularly the effect of various vortex distributions on the blade shape. Tests concluded by electrolytic analogy have confirmed the theory.

N. K. H. Scholz, Germany

3533. Strscheletsky, M., Contribution to the study of flow around cascades of airfoils (in German), Voith, Forschung Konstrukt. no. 4, Pap. 16, 6 pp., Nov. 1958.

In the x-y plane an arbitrary curved line is given which is imposed with a given continuous vortex distribution γ. Wanted are the velocities in the whole x-y plane, induced from this vortex distribution. For points on the lifting line itself the integral is singular, and Cauchy's principal value has to be determined. The integration can be carried out graphically or numerically, when the singular point is split off. This separation leads to a singular integral of the form $I_n(\varphi_A) = \int_{w_1}^{w_2} \frac{\cos n\varphi}{\cos\varphi - \cos\varphi_A} d\varphi$, the calculation of which is possible recurrently. For $w_1 = \varphi_A - \frac{\pi}{30}$, $w_2 = \varphi_A + \frac{\pi}{30}$ and $\varphi_A = k\frac{\pi}{15}$ $(k = 1, \ldots 14)$ the integrals $I_n(\varphi_A)$ for $n = 1, \ldots 10$ are tabulated.

K. Gersten, Germany

3534. Cantrell, H. N., and Fowler, J. E., The aerodynamic design of two-dimensional turbine cascades for incompressible flow with a high-speed computer, *Trans. ASME* **81** D (*J. Basic Engng.*), 3, 349-361, Sept. 1959.

Paper presents a method for design of large turning angle, turbine bucket cascades. The method is based on conformal mapping from the logarithmic hodograph plane. The authors try to choose the constant velocity on the suction side of a blade profile; this velocity distribution is—from two-dimensional boundary-layer theory point of view—very good.

The parameters, leading-edge wedge angle and trailing-edge wedge angle which the designer has to prescribe, are unsuitable for technical purposes; the thickness of a blade profile, which is a more suitable parameter from dynamical grounds, cannot be chosen by the designer.

The method as presently constituted is limited to the design of blades with sharp leading edge, which is not suitable if the blade works in the off-design conditions.

M. Ruzicka, Czechoslovakia

3535. Turner, R. C., Hargest, T. J., and Burrows, R. A., Stall cell propagation in two mismatched compressor stages, Aero. Res. Counc. Lond. Curr. Pap. 449, 29 pp., 1959.

The results of an experimental investigation are presented. No attempt is made to establish a theoretical correlation with the results other than to note that the one-dimensional criterion for stability is not applicable. The authors intend this, rather, as a contribution to "a general understanding of surging and unsteady flow phenomena . . . ."

An analysis of the difficulties encountered with a hot wire in measuring large velocity fluctuations is presented.

P. J. Mullan, USA

3536. Watanabe, I., and Ando, T., Experimental study on radial turbine, with special reference to the influence of the number of impeller blades on performance characteristics, *Bull. JSME* **2**, 7, 457-462, Aug. 1959.

Experiments were conducted to ascertain the influence of the number of impeller blades on the performance of a radial gas turbine driven by compressed air. Pressures, temperatures, and flow directions were measured. Results indicated that optimum number of blades is greater than that recommended for centrifugal compressor, but varies considerably and inconsistently with weight flow. Entry relative velocity direction was inclined in the direction of rotation 20 to 30 degrees from the 90-degree position. Reviewer feels more analysis is desirable to explain trends and variations in experimental results.

D. G. Huber, Canada

3537. Montgomery, S. R., Spanwise variations of lift in compressor cascades: Part I, Experiments; Part II, Theory, *J. Mech. Engng. Sci.* **1**, 3, 293-311, Dec. 1959.

The need for axial-flow turbomachines to have good performance over a wide range of operating conditions makes it necessary to design the individual stages with radial distributions of tangential velocity different from those which give simple analytical solutions to the equations of motion. Because of this and also the effects of casing boundary layers, the lift force on the blade, as well as the circulation around the blade, will usually vary along the blade span.

The design of the blading in a machine is normally based on the usual strip theory, which is a means of relating the performance of a section of the blade to the performance of a similar airfoil mounted in a wind tunnel. Interference effects due to adjacent blades are allowed for by testing cascades of airfoils, and the change in axial velocity through a stage is corrected by empirical means. In most design methods the effects of spanwise variation of circulation are neglected, and the lack of agreement between the predicted and the actual performance of compressors indicates the need for a detailed investigation of this phenomenon.

An investigation of this spanwise variation is given in Part I, and the allied theoretical work is given in Part II. A simple potential model is used to predict the flow around a blade in a cascade. Calculations show reasonable agreement between theoretical and experimental results. The blade boundary-layer thickness is found to have a significant effect on the circulation.

R. C. Binder, USA

3538. Wood, M. D., Theoretical and experimental studies of stall propagation in rows of axial flow compressor blades, *Aero. Quart.* **10**, 4, 345-360, Nov. 1959.

This is another small-perturbation theory and comparison with experiments. Predicted stall propagation velocity shows poor agreement with experiments for linear cascades and for annular stator, but it shows good agreement with experiment for isolated rotor in which stall was weak. Author attributes cause of disagreement to the size of the disturbance—too large to be treated as a small perturbation.

Y. Senoo, USA

3539. Mellor, G. L., An analysis of axial compressor cascade aerodynamics: Part I, Potential flow analysis with complete solutions for symmetrically cambered airfoil families; Part II, Comparison of potential flow results with experimental data, *Trans. ASME* **81** D (*J. Basic Engng.*), 3, 362-386, Sept. 1959.

Part I of the paper presents a method of computing the incompressible potential flow through a cascade of airfoils. Results are presented in a compact graphical form enabling the potential flow effects of camber, profile thickness, stagger, solidity and angle of attack to be quickly found. In Part II the theory is compared with a large number of NACA 65-series compressor-blade experimental results. One empirical constant is introduced into the theory and this secures quite good agreement between theory and experiment. A semi-empirical theory is also offered for the stalling of cascades. This is interesting, but as it involves no boundary-layer analysis there is some doubt as to what has been achieved.

L. C. Woods, England

3540. Sega, M., and Yokoyama, E., Experimental investigation of axial-compressor inlets, *Bull. JSME* **2**, 7, 451-457, Aug. 1959.

Authors carried out ad hoc experiments on seven models of an axial flow compressor inlet to determine effect of passage shape on velocity distribution and losses before blade row. (Axis of inlet was normal to axis of compressor.) Influence of nonuniform velocity on stall is discussed briefly. No general conclusions are made; authors found it difficult to obtain uniform velocity distribution.

R. A. A. Bryant, Australia

3541. Wiles, W. F., Wakes in axial compressors, *J. Roy. Aero. Soc.* **63**, 588, 730-731 (Tech. Notes), Dec. 1959.

3542. Vadot, L., The generation of electricity by windmills. Parts I and II (English and French), *Houille Blanche* **13**, 5, 503-539, Oct. 1958; **14**, 1, 3-22, Jan.-Feb. 1959.

Article covers windmill design problems from technical and economic considerations. Formulas and charts are presented which show the shaft power output and the speed of rotation of rotors as a function of wind speed and rotor diameter for standard atmospheric conditions. Variations in wind speed caused by atmospheric turbulence are discussed from the standpoint of their effect on rotor blade stresses and the rated power of the "aerogenerator." Blade design and construction for minimizing stresses are qualitatively discussed.

Analytical expressions, as well as statistical methods, are presented for determining the weight and cost of the entire machine, per unit power produced, as a function of rotor diameter. For certain wind conditions and type of machine, it is shown that the lowest cost per kw is produced with rotor diameters ranging from 24 to 30 meters.

Article concludes with statement that there is enough wind energy available in the Atlantic regions to warrant a thorough examination of the feasibility of using windmills as power sources.

A. Gessow, USA

3543. Sabinin, G. Kh., On a new scheme for a windmill generator with pneumatic power transmission (in Russian), Prom. Aerodinamika no. 8, Moscow, Oborongiz, 1957, 197-205; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9778.

Some considerations are presented to illustrate the working process of a windmill generator with pneumatic power transmission, suggested by the French engineer Andraux. It is demonstrated that pneumatic transmission from a windmill rotor to an air turbine and the generator shaft has a low efficiency, not exceeding 50%. At the same time, author points out that the advantages of pneumatic transmission as compared with the usual mechanical gearing become so substantial with the increasing power of windmill generator installations that low efficiencies cannot be an obstacle to their application. In conclusion a verification is made

of the experimental results for a British windmill generator with pneumatic power transmission having a rotor diameter $D = 24.4$ M.

A. S. Ginevsky

Courtesy Referativnyi Zhurnal, USSR

3544. Vashkevich, K. P., An investigation of the flow structure behind an obliquely-impacted windmill rotor (in Russian), Prom. Aerodinamika no. 8, Moscow, Oborongiz, 1957, 186–196; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9801.

The results are presented of an experimental analysis of the velocity field and angles of obliquity of the incident flow for a high-speed windmill rotor of 2-m diameter. The experiments were made in a wind tunnel with a working section of 6-m diameter. Velocity fields and angles of obliquity were obtained along two mutually perpendicular diameters behind the rotor at rated power, corresponding to a modulus number $Z = 5$, at a distance of 0.65 D from the plane of rotation and angles of incidence y from $0°-60°$. At other than rated output of the windmill rotor the magnitude and direction of the flow velocities were measured only in a single point, situated on the axis of the rotor at a distance of 0.65 D from its plane of rotation, with modulus numbers $Z = 3.5$, 5, 7, 9, and the former angles of incidence. It is demonstrated that with deflection of the head of the windmill rotor in a direction away from the incident flow, within the limits of $y \leqslant 35°-40°$, devices intended for automatically turning the rotor into the wind and placed at a distance of not more than $0.65D$ from the rotor, near its axis of rotation, are working in a flow with a steep velocity gradient at much lower speeds, the degree of reduction in the velocity depending on the instantaneous rating of the windmill rotor. These factors abruptly decrease the efficiency of the arrangements for automatically turning the rotor into the wind.

A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

3545. Bruning, G., The effect of compressibility, down wash and blade tip losses on flapping coefficients and thrust of a helicopter rotor (in German), Z. *Flugwiss.* **7**, 6, 149–163, June 1959.

The theoretical treatment of a helicopter rotor requires a series of drastic omissions regarding flapping motion and generated thrust to attain simple equations. In this paper, the usual omissions regarding compressibility of air, unsteady distribution of induced downwash and loss in lift at the blade tips are dropped. It appears that the formal structure of the conventional formulas remains unaltered. However, far more complex functions depending on advance ratio and blade tip velocity take the place of the simple functions appearing in the simplified theory. These functions are given in the form of tables for the simplest cases.

Compressibility and blade tip losses are shown, in a numerical example, to be two effects which, for blade tip velocities of present day practice, cancel each other almost completely when calculating the thrust. Thus, it is demonstrated that if taking into account one of these effects only, as occasionally practised mainly regarding blade tip losses, the results are worse than if neglecting both effects.

Calculating the flapping coefficients, however, the effects investigated do not cancel each other. Except for the coning angle, the results obtained when taking into account compressibility, a trapezoidal distribution of downwash and blade tip losses, differ considerably from the results obtained if these are neglected.

From author's summary

3546. Heyson, H. H., An evaluation of linearized vortex theory as applied to single and multiple rotors hovering in and out of ground effect, NASA TN D-43, 60 pp., Sept. 1959.

The velocities and the forces acting on a rotor calculated on the basis of the linearized vortex theory are compared with observations and measurements. The linearized vortex theory is based essentially on the following pattern: if the circulation around the helicopter blades is constant with radius, the flow field is represented by a vortex sheet which extends concentrically around the axis of the rotor from the rotor to the ground. When the circulation varies around the rotor blades as it does with untwisted blades, the field is represented by several concentric vortex sheets.

The comparison between the tests and the calculated velocities on a single rotor show that the near field behind the rotor is well predicted by the theory and also the forces acting on the rotor as a function of the distance from the ground (to which the axis of the rotor is perpendicular) is accurately calculated. However, the theory predicts an upwash outside the propeller which does not exist according to the measurements. For a tandem rotor the theory predicts a higher efficiency which is not realized in tests, a result which may at least in part be explained by the discrepancy between the calculated and observed upwash on a single rotor.

It is concluded in general that the good agreement between observation and the simplified vortex theory is rather accidental and cannot be taken for granted in any new and untested configuration of propellers as might be used in a newly designed VTOL aircraft.

A film showing the flow pattern around the experimental model is available on loan from NASA. This film may have interest to a much wider audience than those directly connected with the design of VTOL aircraft, such as university students in fluid flow.

H. P. Eichenberger, USA

3547. McKee, J. W., Experimental investigation of the pressure fluctuations on a flat plate and a cylinder in the slipstream of a hovering rotor, NASA TN D-112, 15 pp., Sept. 1959.

An experimental study has been made of the pressure fluctuations on bodies in the slipstream of a hovering rotor. The slipstream was generated by a 6-ft-diameter two-blade rotor with constant-chord untwisted blades. Pressures were obtained for a 12-inch square plate and a 12-inch-diameter cylinder for a range of positions in the slipstream with the plate and the cylinder axis parallel to the rotor disk.

The surface pressures on the models, referenced to undisturbed atmospheric pressure, were found to have high positive peaks at blade-passage intervals. The peak pressures were most pronounced when the models were positioned close to the plane of the rotor and the pressure orifices were near the edge of the slipstream where they were subject to the highest slipstream dynamic pressure. There were progressive changes of the character of the pressures with change of orifice position around the cylinder (from upwind to downwind) and with change of position in the slipstream. Some complex periodic pressures and random pressures were found in the tests.

From author's summary

Flow and Flight Test Techniques and Measurements

(See also Revs. 3361, 3500, 3507, 3517, 3524, 3535, 3537, 3546, 3547, 3568, 3749, 3767)

3548. Morkovin, M. V., On supersonic wind tunnels with low free-stream disturbances, ASME Trans. **81**E (*J. Appl. Mech.*), 3, 319–324, Sept. 1959.

Useful review of sources of flow disturbances in supersonic tunnel working sections, and means of their suppression when unacceptable (e.g. in stability and transition experiments). Author discusses separately mean-flow nonuniformities; unsteady velocity and entropy (temperature) fluctuations; sound from surface dipole distributions, volume quadrupole distributions and shivering Mach waves.

R. C. Pankhurst, England

3549. Demele, F. A., The effects of an inverse-taper leading-edge flap on the aerodynamic loading characteristics of a 45° sweptback wing at Mach numbers to 0.90 NASA TN D-138, 108 pp., Dec. 1959.

Measurements have been made of the surface pressures on a plane sweptback wing having an inverse-taper leading-edge flap. Deflection of the flap produced a camber and twist distribution similar to that resulting from incorporation of conical camber in the forward portion of the wing. The wing had 45° of leading-edge sweepback, an aspect ratio of 3, and a taper ratio of 0.4. The results of tests of the wing-body combination with flap deflections to 16° are presented for a Mach number of 0.25 at a Reynolds number of 15 million and for Mach numbers of 0.60 to 0.90 at a Reynolds number of 3.2 million.

Deflection of the flap decreased the loss in loading near the wing tip which occurred for the plane wing at Mach numbers of 0.60 and greater. However, only small changes in wing normal force and center of pressure accompanied flap deflection. Deflection of the flap increased the maximum flap-section normal force and hinge moment by as much as 100%.

From author's summary

3550. Carlson, H. W., An investigation of some aspects of the sonic boom by means of wind-tunnel measurements of pressures about several bodies at a Mach number of 2.01, NASA TN D-161, 44 pp., Dec. 1959.

An investigation of some aspects of the sonic boom has been made with the aid of wind-tunnel measurements of the pressure distributions about bodies of various shapes. The tests were made in the Langley 4- by 4-ft supersonic pressure tunnel at a Mach number of 2.01 and at a Reynolds number per foot of 2.5×10^6. Measurements of the pressure field were made at orifices in the surface of a boundary-layer bypass plate. The models which represented both fuselage and wing types of thickness distributions were small enough to allow measurements as far away as 8 body lengths or 64 chords. The results are compared with estimates made using existing theory.

To the first order, the boom-producing pressure rise across the bow shock is dependent on the longitudinal development of body area and not on local details. Nonaxisymmetrical shapes may be replaced by equivalent bodies of revolution to obtain satisfactory theoretical estimates of the far-field pressures.

From author's summary

3551. Peck, R. F., Jet effects on longitudinal trim of an airplane configuration measured at Mach numbers between 1.2 and 1.8, NASA TN D-177, 17 pp., Dec. 1959.

A rocket-powered delta-wing airplane model was tested at Mach numbers up to 1.8. The configuration tested had a relatively small horizontal tail mounted just behind and above the exit of a rocket nozzle. The results indicated that the model encountered large jet-induced effects on longitudinal trim between Mach numbers of 1.2 and 1.8. These effects are believed to have resulted from the fact that the horizontal tail either intersected or was very close behind a shock wave in the external flow originating near the intersection of the external flow and the jet boundary. The induced normal load at the tail was calculated to be approximately 10% of the static thrust of the rocket.

From author's summary

3552. Fortini, A., Performance investigation of a nonpumping rocket-ejector system for altitude simulation, NASA TN D-257, 33 pp., Dec. 1959.

The effect of various dimensions on the performance of a prototype, nonpumping cylindrical-rocket-ejector system was studied both theoretically and experimentally. The rocket-ejector system contained a convergent-divergent nozzle with a nozzle exit-to-throat area ratio of 9. Various length and diameter ejector tubes enclosed the nozzle. High-pressure nitrogen gas flowed through the nozzle and served as the pumping fluid.

The cross-sectional area ratio of ejector tube to nozzle throat and the ratio of ejector-tube length to diameter were investigated. A range of ejector-tube area ratios from 16 to 49 and ejector-tube length-to-diameter ratios from 2.67 to 12.0 was studied for various ratios of pumping pressure to atmospheric pressure. The range for the pumping pressure ratios was from 3 to 44.

It was found experimentally that the pumping fluid leaving the nozzle can evacuate its own environment to an approximate optimum value of 0.025 atmosphere. This minimum value (0.025 atmosphere) appears to be a function of pumping-fluid pressure and ejector-tube area ratio, provided the ejector tube has sufficient length. For ejectors not having sufficient length, the minimum value (different from the optimum) becomes a function of pumping-fluid pressure and ejector length-to-diameter ratio.

A model of the ejector flow phenomenon was deduced from experimental observations. From the model, a theory for obtaining ejector performance was developed. A comparison of the theory with experimental results is reported.

From author's summary

3553. Naeseth, R. L., and Davenport, E. E., Investigation of double slotted flaps on a swept-wing transport model, NASA TN D-103, 33 pp., Oct. 1959.

A low-speed wind-tunnel investigation has been made at a Reynolds number of 0.9×10^6 to determine the longitudinal aerodynamic characteristics of a double-slotted flap on a wing swept back 35° at the quarter chord. The wing had an aspect ratio of 7 and a taper ratio of 0.3. The flap was 0.33 wing chord and the vane was 0.50 flap chord.

A maximum lift coefficient of 2.2 was obtained with the double-slotted flap in conjunction with a leading-edge slat. The lift coefficient increment at $\alpha = 0°$ and $\delta_f = 70.7°$ was 1.43. This value was predicted by a method presented in NACA Technical Note 3911.

The method of design of the flap was based largely on two-dimensional double-slotted-flap results. Changes to the geometry of the flap indicated only small improvements in lift characteristics. Also, alterations which involved sealing one or both slots resulted in losses in lift and increases in drag at high lift coefficient.

Large diving moments were encountered which would have required a tail download for trim amounting to a lift-coefficient increment of as much as 0.17. This analysis assumes a tail length of three mean aerodynamic chords and a center of gravity located at 0.3 mean aerodynamic chord, which are typical characteristics of present swept-wing transport designs.

From authors' summary

3554. Richardson, N. R., and Pearson, A. O., Wind-tunnel calibrations of a combined pitot-static tube, vane-type flow-direction transmitter, and stagnation-temperature element at Mach numbers from 0.60 to 2.87, NASA TN D-122, 26 pp., Oct. 1959.

Calibration tests of a combined pitot-static tube, vane-type flow-direction transmitter, and stagnation-temperature element have been conducted over a range of Mach numbers from 0.60 to 2.87 in the Langley 8-ft transonic pressure tunnel and in the Langley Unitary Plan wind tunnel. The results indicate that the variations in static-pressure error due to angle of attack were generally less than 1% of the impact pressure for angles up to 15°, whereas the variations due to a sideslip angle of ± 10° ranged from 2 to 4%, depending on the Mach number. The effects of angles of attack from −3° to 20° and/or angles of sideslip from −10° to 10° on the measurement of total pressure were less than one-half of 1% of the impact pressure. The angle-of-attack vane

indicated too high an angle with an error at 15° ranging from 0.5° to 2.4°, depending on the Mach number. The sideslip-vane errors ranged from zero of 1.5° for sideslip angles to ±10°. There were no significant variations in the measured stagnation temperature due to angles of attack from about −3° to 20° and/or angles of sideslip from −10° to 10°.

From authors' summary

3555. Taylor, R. T., Wind-tunnel investigation of effect of ratio of wing chord to propeller diameter with addition of slats on the aerodynamic characteristics of tilt-wing VTOL configurations in the transition speed range, NASA TN D-17, 42 pp., Sept. 1959.

An investigation has been made in the Langely 3000-mph 7- by 10-ft tunnel to determine the effect of changes in wing chord and the effect of addition of 0.15c leading-edge slats on the longitudinal aerodynamic characteristics of a small wing-propeller combination simulating a twin-engine, tilt-wing, vertical-take-off-and-landing aircraft.

Increases in wing chord serve to reduce the severity of the stall in the transition speed range. Extending a 0.15c leading-edge slat also decreases the severity of the stall but in some cases gives sizable nose-up pitching moments. From author's summary

3556. Kelly, M. W., Tolhurst, W. H., Jr., and Maki, R. L., Full-scale wind-tunnel tests of a low-aspect-ratio, straight-wing airplane with blowing boundary-layer control on leading- and trailing-edge flaps, NASA TN D-135, 24 pp., Sept. 1959.

A full-scale wind-tunnel investigation was made to determine the effects of boundary-layer control on the leading- and trailing-edge flaps of a fighter-type airplane having a thin, unswept, low-aspect-ratio wing.

It was found that, with the leading- and trailing-edge flaps deflected 45°, the application of boundary-layer control resulted in significant increases in maximum lift, aileron effectiveness, and longitudinal stability at high angles of attack. With the leading-edge flaps deflected 30°, the only appreciable effect of applying boundary-layer control to the leading-edge flap was to increase the aileron effectiveness between angles of attack of 15° and 19° It was also determined that the air-flow requirements of the boundary-layer control systems were well within the capabilities of the compressor bleed-air system of the turbojet engine used in the airplane. From authors' summary

3557. Beastall, D., and Winyard, A., A frost-point hygrometer for supersonic wind tunnels (with addendum), Aero. Res. Counc. Lond. Rep. Mem. 3112, 9 pp., 1959.

This report describes a frost-point hygrometer suitable for measuring the water-vapor content of the air in supersonic wind tunnels at any stagnation pressure within their present range of operation. It uses CO_2 as a coolant and is economical in construction and operation. From authors' summary

3558. Stanbrook, A., Experimental observation of vortices in wing-body junctions, Aero. Res. Counc. Lond. Rep. Mem. 3114, 22 pp., 1959.

Tests have been made on various wing-body combinations to investigate the nature of the flow in the junction. It was found that vortices are formed due to separtaion of the boundary layer on the body in the flow toward the wing. The free edge of the resulting vortex sheet rolls up to form the vortex which then trails downstream around the wing. As incidence is increased the vortex on the suction side of the wing moves toward the wing and the vortex on the pressure side moves away from the wing.

The vortices are present with both swept and unswept rounded leading edges at subsonic and supersonic speeds but were not found with sharp leading edges at zero incidence.

From author's summary

3559. Lawford, J. A., Measurements of velocity fluctuations in the working section of the R. A. E. 4-ft × 3-ft wind tunnel with flow disturbances in the second diffuser, Aero Res. Counc. Lond. Curr. Pap. 455, 8 pp., 1959.

An attempt has been made to determine whether a large contraction ratio and wire gauze screens in the maximum section would prevent unsteadiness of flow in the return circuit from affecting the flow in the working section.

Flow disturbances were produced in the second diffuser of the R.A.E. 4-ft × 3-ft wind tunnel by means of a large fixed flap or a pair of oscillating flaps. The disturbances obtained by these means were less than had been anticipated, but it was found that a very large flap had no measurable effect on turbulence in the working section. Velocity distributions were not measured in the working section, but since a complete traverse on the vertical centerline showed no effect on the turbulence, it is felt that the velocity distribution was probably not affected.

From author's summary

3560. Wittliff, C. E., and Rudinger, G., Summary of instrumentation development and aerodynamic research in a hypersonic shock tunnel, WADC TR 58-401, Part 1, (PB 151 488; ASTIA AD 155 758), 65 pp., Aug. 1958.

A detailed and informative engineering report covers work in the Cornell Aeronautical Laboratory shock tunnel between 1954 and 1958. Instrumentation and some test data for local heat-transfer and aerodynamic forces on a cone at angle of attack are discussed.

In such a rapidly-developing field of research, this report (dated August 1958) may already seem significantly out of date, but to a beginner in shock-tunnel research it whould be quite valuable.

F. S. Sherman, USA

3561. Bray, K. N. C., and East, R. A., A progress report on the University of Southampton hypersonic gun tunnel, Aero. Res. Counc. Lond. Curr. Pap. 457, 31 pp., 1959.

This note is intended as a brief report on progress made with the Southampton University hypersonic gun tunnel during the first six months since it become operational. It includes a description of the mechanical construction of the tunnel and the instrumentation that has been developed for it, together with some preliminary measurements designed to test the steadiness and uniformity of the flow. From authors' summary

3562. Schultz, D., Microwave technique applied to the investigation of ionized gases in shock tubes, Aero. Res. Counc. Lond. Curr. Pap. 436, 12 pp., 1959.

A brief review is given of some techniques which employ the radiation and transmission of millimeter and centimeter wavelength electromagnetic waves. Such techniques may be of use in studies of electron density and ionization-recombination phenomena which are at present of interest in hypersonic flow.

From author's summary

3563. Russell, W. R., Sjoberg, S. A. and Alford, W. L., Flight investigations of automatic stabilization of an airplane having static longitudinal instability, NASA TN D-173, 32 pp., Dec. 1959.

A flight research program utilizing a subsonic jet-propelled fighter airplane was conducted to investigate the capabilities of three types of automatic stabilization and control systems in stabilizing airplanes having aerodynamic static longitudinal instability. The systems investigated were a normal-acceleration-command control system, a pitch-rate-command control system, and a pitch-damper system. The center-of-gravity range covered was from about 4% of the mean aerodynamic chord forward of the stick-fixed maneuver point of the basic airplane to about 4% of the mean

aerodynamic chord behind the stick-fixed maneuver point of the basic airplane.

With the center of gravity 4% of the mean aerodynamic chord behind the maneuver point and at a Mach number of 0.6 at an altitude of 30,000 feet, the time required for a disturbance in normal acceleration to double in amplitude was about 1 second and the force gradient was about −6 pounds per g. With these stability characteristics the pilots doubted that any type of military mission could be accomplished and felt that landings would be very difficult and dangerous. When flying the unstable airplane with any of the three automatic stabilization and control systems, the flying qualities were definitely superior to those of the basic airplane. The pilots were of the opinion that they could control the unstable airplane through the normal-acceleration control system as easily and accurately as they could control the stable airplane with the manual control system. From authors' summary

3564. Thompson, W. C., Rough-water ditching investigation of a model of a jet transport with the landing gear extended and with various ditching aids, NASA TN D-101, 33 pp., Oct. 1959.

The rough-water ditching characteristics of a jet transport airplane with the landing gear extended and with various ditching aids were investigated at the Langley tank catapult. A dynamic model with certain portions of the model approximately scale strength was used to determine the probable ditching behavior and to some extent the resultant damage. The ditching aids included two sets of twin hydro-skis, two sets of twin hydrofoils, and a single hydrofoil. The rough-water tests were made in waves 4 feet high by 200 feet long and 4 feet high by 120 feet long (full scale). Data were obtained from visual observations, acceleration records, and motion pictures.

A rough-water ditching with the landing gear retracted will likely result in most of the fuselage bottom being torn away and the airplane sinking within a very short time. Ditching with the landing gear extended will likely result in a drive if the main gear does not fail or in a deep run with appreciable damage throughout the fuselage bottom if the main gear fails. Hydro-skis or hydrofoils may be used to improve the ditching performance and minimize the amount of damage of the fuselage boottm.

From author's summary

3565 Russell, W. R., and Alford, W. L., Flight investigation of a centrally located rigid force control stick used with electronic control systems in a fighter airplane, NASA TN D-102, 30 pp., Sept. 1959.

A flight investigation was made to evaluate a rigid, nonmoving, centrally located force stick as a maneuvering flight controller for a fighter airplane. The force stick was similar in size and location to a conventional control stick and was used with both a rate-type command control system and an irreversible electronic power control system. Included in the flying were pullups, turns, aileron rolls, rough-air flying, stall approaches, and landings.

In the opinion of the pilots the centrally located rigid force stick was not as suitable for use as a maneuvering controller for a fighter airplane as a displacement-type control stick. Although the pilots did not find the lack of stick displacement to be greatly objectionable, they were of the opinion that some stick motion was desirable.

The longitudinal control characteristics were satisfactory. No longitudinal sensitivity problems were encountered. The pilots preferred a stick force gradient of about 5 pounds per g except at indicated airspeeds below 150 knots where the preferred force gradient was slightly higher.

The lateral control characteristics generally were unsatisfactory. At indicated airspeeds above 150 knots the pilots found it difficult to maintain a constant rolling velocity. The undesired rolling motions were evident primarily as low-amplitude variations in rolling acceleration. The undesired rolling accelerations were annoying to the pilot and made precision flying difficult. They resulted from the lack of stick displacement, lack of stick friction, and the short response time of the control-system-airplane combination. From authors' summary

Thermodynamics

(See also Revs. 3619, 3686)

3566. Sinanoglu, O., and Pitzer, K. S., Equation of state and thermodynamic properties of gases at high temperatures: Part 1, Diatomic molecules, *J. Chem. Phys.* **31**, 4, 960-967, Oct. 1959.

The virial coefficient approach is recommended for describing imperfections in assemblies of chemically reacting unionized atoms. A method is presented for obtaining the second virial coefficient, including the quantum correction.

A. Sesonske, USA

3567. Karamcheti, K., A note on the thermal conductivity of solid nitrogen and the direct condensation of nitrogen gas into a solid, AFOSR TN 59-183 (Univ. So. Calif. Engng. Center Rep. 56-206; ASTIA AD 211 323), 13 pp., Jan. 1959.

In the University of Southern California low-density tunnel designed to operate on the "two-phase" principle, nitrogen gas is used as the working medium. Downstream of the test section, the gas is condensed directly into a solid by exposing the gas to a refrigerated surface maintained at a constant temperature (in the range of 15 to 30K). To estimate the condensation rate (i.e., the mass of nitrogen condensed per unit time) per unit area of the surface the problem is treated from the point of view of one-dimensional unsteady heat conduction through the growing layer of the solid condensate. An analytical solution of the problem is obtained. It is seen that the condensation rate can be evaluated once the density, the specific heat, the latent heat of sublimation, and the thermal conductivity k of solid nitrogen are known. While the other quantities are known, k is not known. The analysis is, therefore, used in conjunction with some test data, where the growth with time of the condensate thickness is measured, to obtain an estimate for k. This turns out to be 2.455×10^{-4} cal/sec/cm °K. Using this value of k, relations are given for the condensate thickness and the condensation rate at any time.

From author's summary

3568. Kestin, J., and Leidenfrost, W., An absolute determination of the viscosity of eleven gases over a range of pressures (in English), *Physica* **25**, 11, 1033-1062, Nov. 1959.

The measurements described in the paper were based on a new theory of the oscillating-disk viscometer which includes the effect of the finite radius as well as that of its cylindrical circumference. The theory is first compared with very precise measurements obtained in an instrument a brief description of which is also given. The experiments verify the theory to within 0.15% when no correction for the paddle effect of the mirror is applied. The latter has been determined empirically with respect to measurements on air and with it, it is permissible to assume that the theory holds exactly when the boundary-layer thickness is large enough, as assumed in Newell's theory. The precise lower bound of the boundary-layer thickness for which Newell's theory is applicable has been determined experimentally with reference to measurements on nitrogen.

The final measurements performed at 20 C for air, argon, carbon dioxide, deuterium, helium, hydrogen, krypton, neon, nitrogen, oxygen, and water vapor, and, in addition, at 25 C for air, argon, nitrogen, oxygen, and xenon are believed to be accurate, on an

absolute basis, to 0.05% and precise to 0.01—0.07%, depending on the gas.

A thorough statistical analysis of the present measurements and those due to Michels and Gibson on nitrogen is given. This shows that apart from being subject to a much larger standard deviation, the latter results are statistically identical with the present measurements over the same range of pressures. It is, consequently, believed that the reliability of both sets of data is very high because they have been obtained by entirely different methods.

Extensive numerical results and interpolation formulas are given. From authors' summary

3569. Shifrin, A. S., Viscosity of steam at atmospheric pressure (in Russian), *Teploenergetika* **6,** 9, 22–27, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. S–142, 10 pp.)

Results are explained of an experimental investigation of the viscosity of steam at temperatures from 149–866 C at atmospheric pressure. A two-capillary method, underlying the investigation, is described. A comparison is made with results of other investigations and equations are proposed which will describe the temperature dependence of the viscosity of steam.

From author's summary

3570. Kirillin, V. A., and Ulybin, S. A., Analysis of the accuracy and composite table of experimental values of the specific volumes of water and water vapor obtained in the Moscow Power Institute (in Russian), *Teploenergetika* **6,** 9, 3–6, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. K–199, 6 pp.)

An analysis is made of the accuracy of experimental values of the specific volumes of water and water vapor obtained in the MPI. Tables are presented of reliable and of inadequately exact values of the specific volumes.

From authors' summary

3571. Sirota, A. M., and Mal'tsev, B. K., Experimental investigation of the specific heat of water at 10–500°C temperatures and pressures to 500 kg/cm² (in Russian), *Teploenergetika* **6,** 9, 7–15, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. S–137, 15 pp.)

A new experimental apparatus is described for the measurement of the specific heat of water c_p at supercritical pressures. Results are presented of measurements at pressures up to 500 kg/cm² and 10–500 C temperatures. The lower pressure limit is the saturation curve at temperatures up to 285 C and 300 kg/cm² for higher temperatures. The results obtained are compared with the data of other researchers. From authors' summary

3572. Sirota, A. M., and Beliakova, P. E., On the caloric properties of water at pressures up to 500 kg/cm² and temperatures up to 300°C (in Russian), *Teploenergetika* **6,** 10, 67–70, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. S–138, 6 pp.)

New experimental data on the c_p of water are compared with results of measurements by other authors and with the results of calculating c_p according to p, v, T data. The enthalpy of water has been computed for pressures up to 500 kg/cm² and temperatures to 300 C. From authors' summary

3573. Vukalovich, M. P., Zubarev, V. N., Aleksandrov, A. A., and Kalinin, Iu. Ia., Experimental determination of the specific volumes of water up to 1200 kg/cm² pressures (in Russian), *Teploenergetika* **6,** 10, 74–77, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. V–139, 6 pp.)

Experimental data are presented on the specific volumes of water up to pressures of 1200 kg/cm² and 300 C temperature and these data are compared with the results of other investigations.

From authors' summary

3574. Dahlberg, R., Theory of thermoelectric refrigeration (in German), Z. *angew. Phys.* **10,** 8, 361–368, Aug. 1958.

Paper briefly reviews development of theory during this century, first comparing various suggested "effectivity numbers" for thermoelectric materials and thermocouples. The author's previously suggested "work factor," here modified to allow for contact resistance, is used as a parameter to give the maximum temperature difference in terms of the applied voltage factor. From this the coefficient of performance for general rather than special cases is developed, with the thermal loading (ratio of actual to maximum heat extraction) as parameter.

Paper then considers performance of multistage thermopiles (temperature differences in series) and indicates graphically the gains in performance expected. Finally, paper reviews possibilities of further advances by manipulation of the ratio of conductivities of heat and electricity, using the tunnel-effect in semiconductor. Author points out that if the properties of electron gases could be employed the use of thermoelectric effects for both reversed and direct "heat engines" would become competitive.

Reviewer finds this a stimulating paper. Mathematics depends considerably on the results of the extensive number of references. For an introduction to the subject reviewer recommends *Engineering* **188,** 4871, pp. 97 et seq., Aug. 28–Sept. 11, 1959.

D. Wilson, Nigeria

3575. Vallin, J., Thermoelectric refrigeration (in Swedish), *Klytekh. Tidskr.* **18,** 6, 130–133, Dec. 1959.

3576. Sirota, A. M., and Mal'tsev, B. K., On a gold-platinum thermocouple (in Russian), *Izmer. Tekhn.* no. 8, 27–28, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. S–139, 4 pp.)

3577. Greenshields, D. H., Spectrographic temperature measurements in a carbon-arc-powered air jet, NASA TN D–169, 24 pp., Dec. 1959.

Free-stream temperatures in a carbon-arc-powered air jet have been measured in the range 3,700 K to 5,400 K by using a spectrographic method derived by combining the work of J. A. Smit [Thesis, Univ. Utrecht, 1950] with that of Knauss and McCay [*Phys. Rev.* 1937]. The combined method utilizes the band radiation of the cyanogen molecule and depends upon the rotational energies of this species. The theoretically calculated line intensities have been presented in such a way as to require a minimum amount of refinement and procedure in the measurement application. The apparatus for such a measurement is described, and some representative measurements made on the 700-kilowatt electric-arc-powered air jet of the Langley Research Center are given and discussed. From author's summary

3578. Swindells, J. F., Calibration of liquid-in-glass thermometers, Nat. Bur. Stands. Circ. 600, 21 pp., Jan. 1959.

This Circular contains information of general interest to both manufacturers and users of liquid-in-glass thermometers, as well as those who wish to calibrate thermometers or submit them to the National Bureau of Standards for calibration. Important elements of thermometer design are discussed, and eligibility requirements for certificates or reports of tests are given. Factors affecting the use of common types of liquid-in-glass thermometers are included together with tables of tolerances and reasonably attainable accuracies. The calculation of corrections for the temperature of the emergent stem is given in detail for various types of

thermometers and conditions of use. The Circular also describes the techniques and equipment used in the calibration procedures and provides instructions for applicants requesting thermometer calibration services. From author's summary

Heat and Mass Transfer

(See also Revs. 3269, 3270, 3439, 3461, 3492, 3500, 3508, 3514, 3526, 3560, 3574, 3577, 3624, 3626, 3627, 3629, 3636, 3739, 3757)

3579. Davies, W., Thermal transients in graphite-copper contacts, *Brit. J. Appl. Phys.* **10**, 12, 516–522, Dec. 1959.

The effective surface in contact is assumed to consist of numerous small circular disks which are separated to such an extent that they do not interact electrically or thermally. By applying the differential equation of thermal conduction the distribution of temperature around any of the disks is deduced quantitatively. In the course of the deduction, various approximations are made which appear to be reasonably justified.

Assuming that the current is on for 10^{-4} sec and the metallic surface is free from oxide, an analytical expression for the distribution of temperature is obtained. From this result the greatest rise of temperature in graphite is found to be 50 C. A similar deduction is performed on the assumption that the metallic surface is covered by an oxide film; the greatest rise of temperature in graphite is, in this case, 70 C; this figure, however, is presumably too low because the thermal resistance of the film had not been taken into account. Finally the rate of cooling is deduced assuming that the electrical contact had been broken.

R. Eisenschitz, England

3580. Stein, R. P., A solution of the steady linear heat-flow equation with heat generation and conductivity arbitrary functions of temperature, *ASME Trans.* **81E** (*J. Appl. Mech.*), 4, 685–686, Dec. 1959.

Author solves the steady-state *nonlinear* one-dimensional heat-conduction equation with volume heat generation. The heat-conduction equation is transformed to a linear first-order equation in the square of the heat-flux as a function of the temperature. This linear equation can then be integrated; an explicit expression for the heat flux as a function of temperature follows, if the boundary conditions of the problem specify the heat flux and temperature at some point. The equation for the heat flux can be integrated to give the space variable as a function of the temperature. The explicit integrations involved can be carried out numerically.

While the one-dimensional nonlinear heat-conduction equation, with conductivity and heat generation functions of temperature alone, is not frequently encountered, reviewer believes this represents a useful solution to this special problem.

F. H. Abernathy, USA

3581. Goldenberg, H., Transient temperature rise due to a line source in a semi-infinite medium, with a radiation boundary condition at the interface, *Brit. J. Appl. Phys.* **10**, 7, 314–317, July 1959.

The problem of the transient temperature rise due to a line source in a semi-infinite medium, with a radiation boundary condition at an interface parallel to the line source, is solved. An approximate formula and an error bound are given for the deviation between this solution and the solution subject to an isothermal boundary condition at the interface. A condition is given for the validity of Neher's approximate formula for the steady-state temperature. In a typical example it is shown that the temperature rise above ambient at the surface of a buried cable differs negligibly when the two types of boundary condition are assumed valid at the earth's surface.

From author's summary by W. L. Sibbitt, USA

3582. Clauss, J., and Ritzi, M., Temperature distribution in nuclear reactors (in German), *ZVDI* **101**, 20, 825–831, July 1959.

3583. Mirsepassi, T. J., Steady-state temperature distribution in solids undergoing certain change of property, *Brit. J. Appl. Phys.* **10**, 12, 538–542, Dec. 1959.

A steady flow of heat is conducted through a solid body which consists of layers of different materials. By two isothermal surfaces within a homogeneous layer, three regions in the body are defined where the temperatures are given in terms of three functions $t_j(x, y, z)$; $j = 1, 2, 3$. Let the distribution of temperature be varied by substituting an alternative material in the volume between the two isothermal surfaces, whereby the external boundary conditions are preserved. The resulting new steady distribution of the temperature is specified by three functions $T_j(x, y, z)$. It is shown that $T_j = \alpha_j t_j + \beta_j$, where α_j and β_j are constants. These six constants are fully determined in terms of the known properties of the materials and the original distribution of the temperature. Their determination requires only simple algebra.

The result obtained can be applied to high-temperature processes where frequently the properties of materials vary slowly in consequence of chemical change or similar effects. As an example the penetration of molten iron into the bottom of blast furnaces is considered in some detail.

R. Eisenschitz, England

3584. Dewey, C. F., Jr., Schlesinger, S. I., and Sashkin, L., Temperature profiles in a finite solid with moving boundary, *J. Aero/Space Sci.* **27**, 1, 59–64, Jan. 1960.

Radially symmetric temperature distributions for a solid with boundary ablation are solved. Method uses finite difference techniques with moving boundary by transformation to fixed boundary and time/space dependent finite difference coefficients. Marching solutions on an electronic computor are outlined. Re-entry problems are discussed. E. H. Mansfield, England

3585. Grigorian, S. S., On heating and melting of a solid body owing to friction, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22**, 5, 815–825, 1958. (Pergamon Press, 122 E. 55th St., New York, N. Y.)

Two problems of heating and melting of a solid body by friction are considered; namely friction between two solids and friction between a solid and a viscous incompressible liquid flowing about it. The mathematical solutions make use of dimensional analysis techniques described in Sedov's book. However, lack of a clear concise explanation of terms used and omission of many detailed steps renders this paper impossible to follow by the average engineer. The reviewer would have liked, if time permitted, to compare this paper with the comprehensive work on the melting problem accomplished at MIT a few years ago.

R. J. Mindak, USA

3586. Cess, R. D., and Shaffer, E. C., Heat transfer to laminar flow between parallel plates with a prescribed wall heat flux, *Appl. Scient. Res.* (*A*) **8**, 5, 339–344, 1959.

The temperature distribution is derived for fully developed laminar flow between parallel flat plates with a prescribed constant heat flux q_w at both walls. The first three eigenvalues and constants, as well as asymptotic expressions for these quantities, pertinent to this problem are presented. Reader is assumed to be familiar with certain previously obtained results. An expression, in the form of an integral, is also given for the wall temperature distribution for an arbitrary variable heat flux $q_w(x)$.

M. Morduchow, USA

3587. Kreith, F., and Margolis, D., Heat transfer and friction in turbulent vortex flow, *Appl. Scient. Res.* (*A*) **8**, 6, 457–473, 1959.

The introduction of coiled wires and twisted strips inside a tube to induce swirl was found to increase heat-transfer coefficients by

as much as a factor of 4, but reduced pumping power per unit rate of heat transfer. At comparable Reynolds numbers and swirling motions, the heat-transfer coefficients for air were smaller than those for water. Data are presented as the ratio of swirling flow Nusselt number to axial flow Nusselt number versus Reynolds number. Although no quantitative analysis is attempted, paper includes suitable qualitative discussion.

A. Sesonske, USA

3588. Squire, W., An extended Reynolds analogy, Proc. 6th Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 16-33.

Previous formulas of heat transfer in a circular pipe are discussed specially for the high and low Prandtl number range. A simple derivation is proposed, assuming mainly a temperature defect law similar to the velocity defect law, both laws being supposed to apply to the entire cross section except for the laminar layer at the wall. Besides dropping the law of the wall, paper abandons the usual criterion locating the edge of the laminar layer.

Reviewer welcomes any fresh thinking on the subject, but points to the special need of a basic understanding (lacking until now) of all the turbulent transport phenomena.

A. Craya, France

3589. Tirskii, G. A., On non-stationary heat transfer through a system of disks, rotating in a viscous liquid (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 106-107, July 1958.

This short paper is a continuation of a paper reviewed in AMR **12**(1959), Rev. 6286. While the original paper dealt with two disks only, the present paper deals with a system of large coaxial disks rotating at different and variable angular speeds, and they are placed between two stationary end disks. As with the previous paper only method of solution is given, the final result being in the form of partial differential equations to be solved numerically.

Y. R. Mayhew, England

3590. Bourne, D. E., Eddy diffusivities in forced and free convection boundary layers, *J. Aero/Space Sci.* **26**, 7, 459-460 (Readers' Forum), July 1959.

3591. Crane, L. J., Thermal convection from a horizontal wire (in English), *ZAMP* **10**, 5, 453-460, Sept. 1959.

Author presents mathematical solution of boundary-layer equation for natural convection from a long horizontal wire with constant heat flux. Solution is valid for: vertical distance above wire much greater than wire diameter; for a gas whose viscosity and thermal conductivity are proportional to the absolute temperature; for $Pr = 5/9$, exact, and $Pr = 0.733$ (air) within a few percent (author's estimate); for a wide range of density differences. Author indicates mixing region width at height x above wire is of order of $x\,Gr^{-1/4}$, in agreement with Pohlhausen for a vertical plate.

R. J. Fritz, USA

3592. Bourne, D. E., A note on the approximate calculation of the temperature distribution in an incompressible laminar boundary layer over a heated plane surface, *Quart. J. Mech. Appl. Math.* **12**, 3, 337-339, Aug. 1959.

3593. Brown, W. G., and Grassmann, P., The influence of buoyancy on heat transfer and pressure drop for forced flow in vertical tubes (in German), *Forsch. Geb. Ing. Wes.* **25**, 3, 69-78, 1959.

On the basis of available experimental data, authors state that the effect of buoyancy is negligible when Gr/Re, the ratio of Grashof number to Reynolds number, is less than 50. Theoretical solutions are presented for fully developed laminar heat transfer in circular vertical tubes kept at constant temperature, and the pressure drop and the rate of heat flow at the wall are calculated. Both cases when $\partial T/\partial x = T'$ (constant) $\gtrless 0$ are treated. A comparison with the experimental results is also made.

S. D. Nigam, India

3594. Leadon, B. M., Some experimental techniques in mass transfer cooling, *Aero/Space Engng.* **18**, 10, 28-32, 99, Oct. 1959.

Author introduces his survey by a brief review of the history of investigations dealing with boundary layers on impermeable solid surfaces, and notes that no true theory exists for turbulent boundary layers, the success of studies in this area having been due to the introduction of artificial, if ingenious, assumptions which permitted empirical correlations of data. The terminology introduced by the author for distinguishing the different situations involving mass transfer from the wall to the stream may give rise to some objections. For instance, "film cooling" need not refer only to the injection of a liquid, since applications involving gas film cooling exist. Also, his restriction of the term "transpiration cooling" to refer to the injection through a porous surface of a gas only of the same composition as the exterior stream does not enjoy universal usage. The influence of mass transfer on heat transfer through laminar boundary layers and on the transition from laminar to turbulent flow is described, with consideration given to the question of the net effect of the stabilizing influence of surface cooling and the destabilizing influence of injection.

Reviewer suggests that author's inaccurate statement to the effect that "...thus far the higher energy conditions do not threaten to involve turbulent injection, so turbulent boundary-layer research enjoys a fairly academic serenity broken only by its own frustrations" be excused on grounds of poetic license, although it ignores the efforts being devoted to the pressing practical problems of erosive burning of solid propellants (possibly the most common example of a complete "aerothermochemical" problem involving distributed surface heat and mass transfer with chemical reaction in a flow system) and of effusion cooling of rocket nozzles, both of which involve turbulent boundary-layer conditions. Author emphasizes the tedious experimental problems involved in research on boundary layers with blowing, and notes the desirability of velocity distribution measurements, especially in turbulent injection layers. The observation that no good data on concentration profiles in the case of the diffusion boundary layer have been published may be an overstatement, since author's bibliography overlooks the work of J. Berger ["Contribution a l'Etude de l'Injection Parietale," Doctor's thesis, University of Paris, *Memorial des Poudres* **38** (Annex), p. 1; Paris, Imprimerie Nationale, 1956].

L. Green, Jr., USA

3595. Bernicker, R. P., An investigation of porous wall cooling, AFOSR TN 59-873 (Mass. Inst. Technol., Naval Supersonic Lab. TR 393), 59 pp., June 1959.

Differential equations are formulated for the heat exchange between a heated porous slab and a coolant flowing through the slab. A capillary channel model is assumed. Solutions are obtained in the form of wall and fluid temperature distributions with Peclet number and convective heat-transfer coefficients as parameters. Thermal conductivities and wall geometry are specified to be values in experimental tests.

Experiments gave correlations of Nusselt number with Peclet number and porosity. Dependence of pressure drop upon mass flow was also measured. Reviewer agrees with author that tests on a wide range of materials would be valuable in generalizing the results.

For greater applicability to experimental check, a condition on input heat flux to exit face of slab was not chosen as a boundary condition in the analysis. This necessitated using two "conservation of energy" conditions [Eq. 12iv and 12v] at the entrance face. Considering previous assumptions, reviewer believes the consistency of these two conditions to be questionable, leading to the physically unattractive result (vid. p. 27) of a double-valued

heat-transfer coefficient for a given fluid inlet-temperature. This difficulty might be averted by specifying a single heat balance condition at each face rather than two at one face. Moreover, input heat flux is of engineering significance in designing transpiration-cooled walls. A. Q. Eschenroeder, USA

3596. Bartle, E. R., and Leadon, B. M., Experimental evaluation of heat transfer with transpiration cooling in a turbulent boundary layer at M = 3.2, *J. Aero/Space Sci.* **27**, 1, 78–80 (Readers' Forum), Jan. 1960.

3597. Sutton, G. W., On the stable shape of a slender ablating graphite body, *J. Aero/Space Sci.* **26**, 10, 681–682 (Readers' Forum), Oct. 1959.

An approximate solution of boundary-layer momentum, diffusion, and continuity equations is given for flow over a slender body of revolution, the surface of which is consumed by a diffusion-controlled chemical reaction. Using the result, the shape that is preserved in form is found from an ordinary differential equation expressing the stoichiometric condition at the boundary. The velocity, V, at which the nose retreats is not found directly from the solution but is a parameter in the equation. An observed constant shape of a burning graphite rod was very close to $y \sim x^{0.6}$ and was accurately fitted by the solution. The best value of V agreed approximately with the observed combustion rate and also was about half the expected rate of consumption of carbon in free molecule flow near the tip of the body. R. L. Pigford, USA

3598. Anderson, R. A., and Brooks, W. A., Jr., Effectiveness of radiation as a structural cooling technique for hypersonic vehicles, *J. Aero/Space Sci.* **27**, 1, 41–48, Jan. 1960.

Hypersonic vehicles flying at an angle of attack are subjected to wide variations in the heat flux at different locations. The stagnation regions have highest heating rates, and the wing lower surface has larger heat input than the upper surface. Heat can be transferred from local hot spots internally by radiation to cooler regions. Two models are studied analytically assuming steady state, an assumption which would be valid for shallow reentry angles. The wing is represented by infinite parallel plates and the leading edge by a two-dimensional rectangular box. Heat balances are formulated for known heat fluxes with transfer by radiation, and the results of numerical calculations are plotted. Using values of heat flux likely to be encountered and properties of currently available thermal insulation, it appears that presently available structural materials could be used for a hypersonic glide vehicle. For wings, insulation weights of approximately 1 lb/ft^2 are required, whereas for stagnation regions 2 to 6 lb/ft^2 are necessary. A. Fuhs, USA

3599. Robbins, W. H., Analysis of the transient radiation heat transfer of an uncooled rocket engine operating outside earth's atmosphere, NASA TN D-62, 25 pp., Dec. 1959.

Direct elementary analysis of the problem. Author concludes "... in general, rapid intermittent operation of uncooled rocket engines in space (periods of 1 hr or less) is impractical." Analysis is correct but, unfortunately, author has mislabeled units of parameter ($V/\varepsilon S$) in text and graphs. Units, from list of symbols, are in (ft), author has used (inches) in calculations and plots; the text and graph legends give [(Btu/(hr)(sq ft/in.)($^\circ R^4$)].

J. G. Bartas, USA

3600. Chambers, R. L., and Somers, E. V., Radiation fin efficiency for one-dimensional heat flow in a circular fin, *ASME Trans.* **81** C (*J. Heat Transfer*), 4, 327–329, Nov. 1959.

The steady-state solution for radiant heat transfer from one side of a thin circular fin was obtained with the use of a digital computer. The results are used to determine fin efficiencies. Only these latter data are presented in the paper. The use of fourth power law in place of linearizing the radiation rate shows that significant error can be introduced if the linear assumption is made. Radiation fin efficiencies are found to be lower than the convective fin efficiencies with a maximum difference of 60%.

R. G. Nevins, USA

3601. Kano, M., Preliminary studies of the angular distribution of the sky radiation in the turbid atmosphere, *Pap. Meteorol. Geophys.* **9**, 3/4, 163–170, Jan. 1959.

The angular distribution of the infrared sky radiation whose wavelength is 8000 Å in the turbid atmosphere, with the various optical thicknesses corresponding to the variation of turbidity, was calculated on the basis of the primary scattering using an effective "step-type" size distribution of the aerosol particles. The calculations were performed for the angular distribution of the above-selected sky radiation in the vertical plane containing the sun and the zenith and also the scattering function. The results obtained are compared with earlier work.

Y. S. Touloukian, USA

3602. Hass, G., Drummeter, L. F., Jr., and Schach, M., Temperature stabilization of highly reflecting spherical satellites, *J. Opt. Soc. Amer.* **49**, 9, 918–924, Sept. 1959.

Based on radiation equation and orbit shape and location, paper discusses parameters determining satellite temperatures, and indicates method of stabilizing temperature through various techniques of controlling shell temperature. For satellites in Vanguard-type orbits, typical variations are given of key parameters (ratio of shell solar absorbance to shell low-temperature emittance, and orbit characteristics). Requirement of high visible reflectance of satellite leads to study of effect of coatings (particularly SiO) on reflectance of materials, which results in plots demonstrating relationships with thickness, wavelength, coating material combinations. Experiment is outlined, equipment sketched and results shown for measuring emittance of SiO-coated aluminum spheres. Coating of Vanguard satellite is described in detail, including apparatus for depositing film on spheres. Finally, satisfactory agreement is shown between predicted and measured temperatures in the Vanguard II satellite.

Reviewer believes introductory analytical summary is useful for student or novice, with real "meat" in emittance/reflectance results, Vanguard coating and Vanguard results.

H. L. Bloom, USA

3603. Treshchov, G. G., An experimental investigation of the process of heat exchange in the superficial ebullition of water (in Russian), *Teploenergetika* no. 5, 44–48, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9994.

By means of high-speed cinematography (15,000 frames/second) an experimental investigation has been made of the mechanism of the surface boiling of water flowing over a horizontally-placed nickel plate. The plate, of 6 × 30 mm dimensions, was attached on the side of a rectangular duct of 20 × 10 mm cross section and served simultaneously as a heater and a resistance thermometer. The experiments were made with heat loadings from 10^6 to 5×10^6 kcal/m^2/hour, pressures from 1.2 to 3.7 atmospheres, water temperatures of 50, 75 and 100°, and a flow velocity of 4 m/sec. A statistical evaluation of the cine-film frames showed that the curve of distribution of the maximum bubble diameter (ratio of the relating number of air bubbles of a given diameter to the magnitude of this diameter) follows a gamma-distribution law. With increase of the heat loading to $2q_0$, where q_0 represents the commencement of ebullition, this curve remains constant, while with increasing pressure, the peak of the curve is displaced toward lower values of the diameter. The probable period of formation of the bubbles, and the mean frequency of their breakaway (shedding) were found to be constant (within 15% error), under changing heat loading (up to $2q_0$) and pressure. The curve of distribution of steam-forming

nuclei z is a curve of standard distribution. With increasing pressure and heat loading, the peak of this curve moves toward higher values of z. The time change in the bubble diameter at pressures up to 4 atmospheres can be described by the equation

$$D = D_M \, [\theta \, e^{1-\theta}]^b \qquad [1]$$

where $\theta = \dfrac{\tau}{\tau_M}$ is the time constant, τ_M, the time from commencement of growth to attainment of the maximum diameter D_M; b a parameter of the individual bubble, with a definite value ($1 < b < 2.5$). Applying the Rayleigh equation and Eq. [1], the problem is analyzed of the pressure change inside the bubble during growth. It is shown that the maximum pressure within the bubble is 2-3 atmospheres higher than in the (ambient) liquid. Measurements of the temperature field in the boundary layer and the data of the high-speed cinematograph recordings enabled evaluation of the quantity of heat transferred to the liquid displaced by the bubble, q_{dis}, and the quantity of heat in the steam contained in the bubble, q_z. The ratio q_{dis}/q_z was found to have a value of 10, and in isolated cases rose to 30.

B. S. Petukhov
Courtesy Referativnyi Zhurnal, USSR

3604. Ismailov, M. I., The theory of convective heat exchange during evaporation (in Uzbek), *Izv. Akad. Nauk UzSSR, Ser. Fiz.-Matem. Nauk* no. 3, 47-62, 1957; *Ref. Zb. Mekb.* no. 9, 1958, Rev. 9987.

The problem is investigated of the convective heat exchange between a current of hot air and a wet flat surface in application to drying processes. The equations of the boundary layer are solved with a number of assumptions (hypothetical length of the mixing path, constant rate of evaporation and constant density, etc.), and using three experimental (empirical) constants, obtained in as yet unpublished researches by the author. The analytical expression

$$N_{mean} = 0.351 \, PR^{2/3} Gu^{1/3}$$

is obtained, wherein

$$Gu = \frac{t_0 - t_m}{t_0}$$

is the Huchmann number; t_0, t_m are the corresponding temperatures of the (hot air) flow and the wet surface.

V. L. Mugalev
Courtesy Referativnyi Zhurnal, USSR

3605. Mikhailov, Yu. A., The influence of similarity conditions on the heat and mass exchange in convective drying (in Latvian), *LatvPSR Zinatnu Akad. Vestis* no. 7, 129-138, 1957; *Ref. Zb. Mekb.* no. 9, 1958, Rev. 10003.

Author reviews the similarity conditions which serve as arguments in the generalized equations of temperature (heat) and mass of the combined substance. The physical significance of the individual conditions or criteria, and their place in the system of relationships governing the processes of transfer of heat and moisture are investigated for the formulations of the external and internal problems respectively. The problem of the interaction between the processes is investigated and, in this connection, simplified relationships are suggested. The exposition is illustrated by numerous charts.

A. A. Gukhman
Courtesy Referativnyi Zhurnal, USSR

3606. Weiss, R., Sublimation of a hemisphere in supersonic flow, AFOSR TN 59-870 (Mass. Inst. Technol., Naval Supersonic Lab. TR 391), 61 pp., July 1959.

This report represents another contribution to the absorption of aerodynamic heating by the ablation process. Hemispheres made of camphor, naphthaline and carbon-dioxide respectively were subjected to the aerodynamic heating in air stream of Mach number 3.5 to study the effect of sublimation of different materials on heat transfer. In addition to experiments at a common Reynolds number of 9.55×10^5, camphor models were also tested at Reynolds numbers of 6.82×10^5 and 4.08×10^5.

Experimental results indicated:

(1) a consistent change in shape of models from hemispherical to conical;
(2) reduction in heat transfer to hemisphere with increase of sublimation mass rate and with increase in Reynolds number;
(3) "lighter" vapors reduce heat transfer more effectively than "heavier" ones.

The reduction in heat transfer due to sublimation was not proved conclusively over the whole range of mass transfer rates and Reynolds numbers. No feasible explanation was given why, at reduced mass transfer rates, heat transfer to tested hemispheres was in fact higher than that for "non-subliming" bodies.

S. Smoleniec, S. Africa

3607. Sherwood, T. K., and Trass, O., Sublimation mass transfer through compressible boundary layers on a flat plate, AFOSR TR 58-131 (Mass. Inst. Technol. Final Rep.; ASTIA AD 203-713), xiv + 317 pp., Sept. 1958.

Sublimation rates of naphthalene were measured from a flat plate with a sharp leading edge, into subsonic ($M = 0.43$) and supersonic ($M = 2$ and 3.5) air flow over the plate. Mass-transfer Stanton numbers were calculated and compared with the predictions of various theories for correlating mass and momentum transfer with Reynolds number (based on distance from leading edge), Prandtl or Schmidt numbers, and Mach number. The agreement of the data with some theories is quite good for turbulent boundary layers. For the laminar boundary layers, the experimental error is too great to permit satisfactory conclusions. For a given Reynolds number, Stanton numbers decrease with increasing Mach numbers, and also with increasing Prandtl or Schmidt numbers.

Naphthalene sublimation is evidently a useful experimental technique for studies in this field.

A. W. Gessner, USA

3608. Saltzman, A. R., Plizak, B. T., Tomko, L. F., and Nycum, J., Regenerative heat sinks for airborne electronic equipment, *Aero/Space Engng.* **18**, 12, 26-31, Dec. 1959.

Analytical investigation was made of possibility of cooling during high-speed flight period by absorption of heat in "packed-bed" exchanger (mass of small particles through which working fluid flows) precooled by atmospheric air during previous (usually longer) low-speed periods of same flight. Analysis shows design is very sensitive to materials used, bed shape, flow conditions, and power to be dissipated; heating or cooling time may vary by ratio of about 100 : 1. Paper is introductory, not giving design information, which requires further analysis and experiment, but is of interest as a study of possibilities.

C. W. Smith, USA

3609. Huber, A., Computation of crossflow recuperators (in German), *Öst. Ing.-Arch.* **13**, 1, 12-17, May 1959.

Author considers Nusselt's formula $(t_{b_{out}} - t_{c_{in}})/(t_{c_{out}} - t_{c_{in}}) = \varphi(x_1, x_2)$ for the inlet and outlet fluid temperatures of a cross-flow heat exchanger, where x_1, x_2 are functions of the heat-exchanger area and the heat capacities of the respective fluids. For a given value of φ an approximate linear relation exists between x_1 and x_2, i.e. $m_1 (\varphi)^{x_1} + m_2(\varphi)^{x_2} - 1 = 0$. Curves are presented for easy determination of m_1 and m_2. Two examples of applications of the above relation to cross-flow heat exchangers are given.

Reviewer does not perceive any advantage of this method over the heat-exchanger effectiveness concept of Kays and London.

W. A. Wolfe, Canada

3610. Rabinovich, G. D., On the analysis of heat-exchange apparatus. Part III, *Soviet Phys.-Tech. Phys.* **3**, 5, 1004–1010, Jan. 1959. (Translation of *Zh. Tekh. Fiz. USSR* **28**, 5, May 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Neglecting the heat capacity of the interface wall the unsteady form of energy equation is written both for the primary and secondary fluids. Parallel and counter flows are considered by means of a transformation. Both cases are reduced to the following partial differential equation $(\partial^2 u/\partial\xi\partial\eta) + u = 0$ with proper boundary conditions. Only the final form of the solutions are given without any intermediate analysis. V. S. Arpaci, USA

3611. Elanchik, G. A., A method for the experimental investigation of air heaters and heating radiators (in Russian), *Vodosnabzheniye i San. Tekhnika* no. 10, 5–10, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9979.

The principles are presented of a method developed by the author for testing heat exchangers. This so-called "method of states" consists in the following: In the presence of steady-state heat exchange and with the exchanger heated by steam, measurements are made of the starting and end temperatures of the air, t_0 and t_1, the steam temperature t, and the weight of flow of the air through the measuring length, $\nu\gamma$ in kg/m^2/sec. The ratio $\vartheta = (t_1 - t_0)/(t' - t'')$ is then calculated, in which $t' - t''$ is the difference between the mean temperatures of the heat-exchanging media in degrees, and the corresponding velocity in the useful cross section of the radiator. From these data a point is plotted with the coordinates $(\nu\gamma, \vartheta)$. The quantity of air passing through the heat exchanger is then varied. An example analysis of the coefficient of heat transfer of a radiator is shown which, according to the author's statements, fully confirms the test results. Curves are given of the results of various tests, and for the heat-engineering calculation of a heating radiator (M-132).

M. N. Chausskii
Courtesy Referativnyi Zhurnal, USSR

3612. Stahlheber, W. H., Extended-surface process heat exchangers, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-37, 8 pp.

3613. Martin, A., Thermal inertia of heat exchanges (in French), *Rev. Univ. Mines* **15**, 6, 611–616, June 1959.

3614. Moskovits, P. D., Low-temperature boiler corrosion and deposits—a literature review, *Indust. Engng. Chem.* **51**, 10, 1305–1313, Oct. 1959.

3615. Aris, R., On the dispersion of a solute by diffusion, convection and exchange between phases, *Proc. Roy. Soc. Lond.* (*A*) **252**, 1271, 538–550, Oct. 1959.

Author considers the dispersion of a soluble matter for flow of liquid and gas phases through an annulus. The separate phases are considered to flow in respective annular regions and to have velocity profiles which are dependent solely upon radial distance. Analysis illustrates the dependence of the Taylor diffusion coefficient upon the ratio of the amounts of solute held in the two phases.

A detailed discussion is given of the special case for which the liquid phase is stationary, and reduction of results to the limiting circular tube and parallel plate geometries is illustrated.

R. Cess, USA

3616. Lauwerier, H. A., A diffusion problem with chemical reaction, *Appl. Scient. Res.* (*A*) **8**, 5, 366–376, 1959.

Steady-state, incompressible, laminar Poiseuille flow in a cylindrical pipe is maintained. A material is injected at a normal plane in this flow in such a manner that its concentration is constant on this plane. The material is permitted to diffuse and react chemically by a first-order homogeneous reaction with a constant specific rate constant. The radial diffusion mass flux is set equal to zero at the wall (no wall reaction), and axial diffusion is neglected. A second-order linear partial differential equation then governs the concentration of the reacting material.

It is shown that this is an eigenvalue problem, and some general properties of the eigenvalues and eigenfunctions are derived. Explicit solutions are obtained for: (a) the concentration profiles when diffusion is entirely negligible; (b) the concentration profiles at large distances from the injection plane when the reaction rate is small; and (c) the concentration at the wall near the injection plane. In (b) an asymptotic solution of the eigenvalue problem is obtained, while in (c) the curvature at the wall is neglected and Laplace transform methods are employed. Reviewer believes that, although there are few real systems for which the model is valid, the analysis is neat and instructive.

F. A. Williams, USA

3617. Swann, W. F. G., Concerning thermal junction resistance in the A. F. Joffe method for measurement of thermal conductivity, *J. Franklin Inst.* **268**, 4, 294–296, Oct. 1959.

The note gives a correction to and elaboration of parts of a previous paper on the same subject [AMR **13**(1960), Rev. 921]. The effect of the thermal resistance at the contact interface between the two blocks is discussed in more detail.

G. G. Thurlow, England

3618. Denisov, P. P., Investigation of thermal coefficients of bunched marine cables, *Soviet Phys.-Tech. Phys.* **4**, 1, 127–130, July 1959. (Translation of *Zh. Tekh. Fiz., USSR* **29**, 1, 141–146, Jan. 1959 by American Institute of Physics, New York, N. Y.)

3619. Kolenko, E. A., Shcherbina, A. G., and Iur'ev, V. G., A method of heat removal from semiconductor refrigerating devices, *Soviet Phys.-Tech. Phys.* **3**, 11, 2329–2331 (Letters to the Editors) June 1959. (Translation of *Zh. Tekh. Fiz., USSR* **28**, 11, 2543–2545, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.) N. Y.)

3620. Kayan, C. F., Influence of hot and cold storage-loads on the refrigerated-space temperature of a cooling complex, *ASME Trans.* **81**B (*J. Engng. Industry*), 4, 339–347, Nov. 1959.

3621. Eckert, E. R. G., Hartnett, J. P., and Irvine, T. F., Jr., A review of heat transfer literature, 1958, *Mech. Engng.* **81**, 7, 44–55, July 1959.

Combustion

(See also Revs. 3272, 3597, 3638, 3640, 3682, 3707)

Book—3622. Semenov, N. N., Some problems of chemical kinetics and reactivity, Vol. 2. (Translated from the Russian by J. E. S. Bradley), New York, Pergamon Press, 1959, x + 168 pp. $5.

This is Volume II of a revised version of a work first published in Russia in 1954. Two separate English translations have appeared. In addition to the present Bradley translation, a paperbound version by Michel Boudart has also been published by the Princeton University Press. There are some differences in arrangements of the two volumes in these translations, but the complete work is the same.

Volume I of the Bradley translation included sections on the reactions of free radicals, or initiation and termination of chains, and on the kinetics of chain reactions. The present volume deals with branched chain reactions and thermal ignition. The effects of branching and degenerate branching in chains are carefully considered, as contrasted to simple or straight chains and thermal ef-

fects. Among the specific reaction systems discussed are the oxidation of phosphorus, sulfur, hydrogen sulfide, and methane and other hydrocarbons, including some work on liquid-phase oxidation.

Brief indices are included and there is also a list of errata and addenda for Volume I.

There is relatively little in this volume to indicate the real progress in work on oxidation reactions since Semenov's original treatise on chain reactions was written in 1935; but it is nonetheless a major exposition of the views of an outstanding school of chemical kinetics. The volume is not, therefore, one to be used as a manual for practitioners in the field of combustion or reactions; but it can be highly recommended for those interested in the fundamental chemical kinetics of such reactions.

R. C. Anderson, USA

3623. Hirschfelder, J. O., and McCone, A., Jr., Theory of flame produced by unimolecular reactions, Parts I and II, Accurate numerical solutions; Ignition temperature and other types of approximations, *Physics of Fluids* **2,** 5, 551–564; 565–574, Sept./Oct. 1959.

These two papers deal with the theory of the propagation of one-dimensional laminar flames. Paper no. I handles the problem on a purely theoretical basis, the flame being assumed to follow the Arrhenius type of chemical reaction. An idealized Bunsen burner with a flat flame surface is considered in which the heat transfer from the flame to the flame holder determines the quenching distance of the flame.

General differential equations for flow systems with chemical reactions are derived and are then solved with the aid of a digital computer. Numerical relationships between the flame velocity, quenching distance, flame thickness, and other parameters are obtained and presented in tables and graphs. The results of these computations confirm the findings of some other investigators that the heat flux at the flame holder should lie between a maximum and a minimum value for a steady flame propagation to take place.

In Paper no. II various types of approximations are made in order to understand clearly the functional relationships obtained in part I. In this context, various methods suggested by investigators such as Comer, Adams, Wilde and Klein, are discussed and compared with the exact solution. Furthermore, a new and simple method of approximation called "ignition temperature approximation" is suggested. It is shown that the results obtained by this latter method are in fairly good agreement with the results of the exact theory.

The papers, though dealing with the simplest of all flames, are useful because simple methods of approximate solutions have been established which give almost the same results as those obtained by an exact mathematical treatment which, however, needs a computer for numerical solution.

Many references are given along with short comments about their contents, which is a welcome innovation.

P. J. Profos, Switzerland

3624. Spalding, D. B., Theory of particle combustion at high pressures, *ARS J.* **29,** 11, 828–835, Nov. 1959.

The equations governing burning time of a fuel particle in an oxidizing atmosphere (or vice versa) are reformulated and solved on a more realistic basis than in the past. The transient term in the energy equation, which takes account of the heating-up of the atmosphere around the particle during the burning, is considered. The equations then predict that the flame radius first increases with time, passes through a maximum, and finally decreases. The transient term becomes particularly important at high pressures. An equation is derived giving the ratio of burning times computed by the usual quasi-steady-state theory and the new point-source transient theory. When this ratio is much smaller than unity, use of the transient theory is recommended. The formulation is also applicable to combustion near or even above the critical pressure of the injected particle.

R. Friedman, USA

3625. Goldenberg, S. A., and Pelevin, V. S., Influence of pressure on rate of flame propagation in turbulent flow, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 590–594.

Laminar and turbulent flame velocities (latter based on inner boundary of luminous flame brush) were determined for gasoline-air mixtures over the pressure range 100 to 760 mm Hg, using a 16-mm burner. Laminar flame velocity U_L was proportional to $P^{-0.25}$; this same pressure dependence was found for turbulent flame velocity U_T when mass flow rate (or Reynolds number Re) was held constant. Cross plots show that for constant approach velocity $U_T \sim P^{0.46}$. For such burner flames various studies have suggested that $U_T = f(U_L, U', l) = \varphi(U_L, Re^n, d^m)$, where U' is turbulence intensity, l is turbulence scale and d is burner diameter. For the single-burner diameter and fixed pressure (760 mm Hg) it was found that $U_T \sim U_L Re^{0.71} \sim P^{-0.25}\,P^{0.71} \sim P^{0.46}$ for variable Reynolds number (or mass flow) and $U_T \sim P^{-0.25}$ for constant mass flow, hence authors consider theory and experiment to be in agreement.

Authors' experimental results for constant mass flow are contrary to those of Khramstov [title source, pp. 609–614; AMR **13** (1960), Rev. 928] and Fine [*Combustion and Flame* **2,** 2, 109–116, June 1958; AMR **12** (1959), Rev. 1545] who both found U_T/U_L proportional to a positive fractional power for propane-air mixtures.

G. L. Dugger, USA

3626. Priem, R. J., and Heidmann, M. F., Vaporization of propellants in rocket engines, *ARS J.* **29,** 11, 836–842, Nov. 1959.

Calculations were made for combustor length required for vaporization of rocket propellant sprays. The one-dimensional theory is based on mass-transfer and heat-transfer rates varying with the square root of Reynolds number. The relative velocity is computed from drag considerations, the drag coefficient being taken to vary with the inverse 0.84 power of Reynolds number. Numerical solutions were obtained. The required length decreases with decreasing drop size and injection velocity and with increasing gas velocity and chamber pressure, and increases in the order: oxygen, fluorine, heptane, ammonia, and hydrazine. Comparisons of experimental combustor efficiencies with these calculations showed good agreement for injector types where the drop size could be calculated. Authors conclude that rocket combustor efficiency is determined by propellant vaporization and is accordingly predictable for known droplet injection conditions.

R. Friedman, USA

3627. Hubbard, E. H., Comparison of different methods of fluid-atomizing oil flames and the effect on flame emissivity and radiation of the addition of carbon black to liquid fuels, *J. Inst. Fuel* **32,** 222, 328–343, July 1959.

Based on the work being done at IJmuiden on the study of radiation from flames, this two-part account compares air and steam as fluids for atomizing fuel oil, as well as the effect of carbon black added to the oil on radiation from the flame. Burner reaction thrust is shown to be the principal variable in a turbulent jet diffusion flame, with the mass of the atomizing agent and the burner profile far less important. Air is superior to steam as the atomizing agent because of better uniformity in the heat-transfer pattern. Preheating the air decreases the mass required for a given momentum, hence an economic balance must be reached between cost of compression and of preheating. Addition of carbon black to a gas oil and a fuel oil increased the heat transfer by radiation because of increased flame emissivity, the emissivity a given distance from the burner increasing with increase in the carbon/hydrogen ratio of the fuel. Although as much as 18% carbon was added to gas oil and 8% to fuel oil, the maximum useful concentration is 5% to minimize difficulties in handling the carbon black-oil mixture.

W. T. Reid, USA

3628. Hagerty, W. W., Glass, D. R., and Yagle, R. A., The effect of fuel spray characteristics on combustion, WADC TR 57-105, 17 pp., Mar. 1957.

Paper describes combustion studies on fuel sprays having varying still-air cone angles, and varying mean volume-to-surface drop sizes. Cone angle and mean drop size were varied by using three kinds of nozzles: a single-port duplex nozzle, and two different dual-flow nozzles. Ease of ignition, stability, and combustion efficiency were investigated in a J-47 combustor, at conditions simulating altitudes of 38,000 and 60,000 ft. The data obtained did not permit precise conclusions, but some general trends were observed, namely: (1) combustion efficiency increased with increasing mean drop size; (2) lean blow-off occurred at lower fuel-air ratios when the mean drop size was smaller; (3) rich blow-off at 15 in. mercury burner pressure occurred at fuel-air ratios less than 33% in excess of normal values, and was unaffected by either cone angle or by mean drop size. The authors warn that these findings are based on limited test ranges, and caution against extending these beyond the narrow ranges studied. Facilities, instrumentation, and procedures are illustrated and described.

K. J. DeJuhasz, USA

3629. Isoda, H., and Kumagai, S., New aspects of droplet combustion, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 523-531.

By observing the combustion of fuel droplets in a zero gravity field (obtained by a falling closed chamber) the importance of natural convection can be assessed. The unique experiments do show that a burning droplet in a zero gravity field is spherically symmetric; burning rate is directly proportional to droplet diameter; the flame diameter increases and then later decreases; and the hot air zone outside the flame expands with time during combustion. A slightly modified Godsave approach for the calculation of burning rate of single droplets is presented and appears to correlate well with the authors' results.

I. Glassman, USA

3630. Winterfeld, G., Similarity parameters of combustion processes in gas turbine combustion chambers (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 94, 40 pp., July 1959.

Tests of a combustion chamber by means of scale model depend on knowledge of conversion factors. In simplest case ("complete similarity") all conversion factors are functions of a single parameter, e.g. mass-flow ratio. Author shows that complete similarity can be achieved only if chemical reagents are the same, mixed in the same proportions, if initial temperature is the same, if scale model is geometrically similar, and if five dimensionless similarity parameters (e.g. Reynolds number) agree. However, for second-order reactions the pressure ratio is the reciprocal of the mass-flow ratio; pressure in scale model consequently may be too high for practical operation. In such case author proposes "partial similarity," obtained by relaxing requirement of equality of Reynolds numbers, while still requiring the other four similarity parameters to agree. As a consequence, geometric similarity of chamber dimensions and of flow pattern cannot be maintained either. Author discusses experimental results and establishes limitations of "partial similarity method" if turbulence or radiation heat loss are excessive.

P. M. Treuenfels, USA

3631. Lazarev, V. P., An investigation of the process in the mixing chamber of a plane-parallel ejector (in Russian), *Sb. Nauchn. Trudi Kuibyshevsk. Industr. In-ta* no. 7(a), 31-41, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9743.

The high-duty axially-symmetric ejector gas burners in present use have a serious structural defect, namely excessive length. To reduce the length of the ejector mixing chamber, ensuring a uniform velocity field, a multi-nozzle slit ejector can be used (plane-parallel ejector).

Article deals with the theoretical and experimental investigation of a plane-parallel ejector. The theoretical construction is based on a modelled turbulent jet in a co-directional flow allowing for the influence of the ejector walls.

Curves of velocity distribution obtained experimentally agree with the data supplied by the author's method with an accuracy up to 2%.

Ya. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR

Prime Movers and Propulsion Devices

(See also Revs. 3267, 3272, 3496, 3520, 3536, 3626, 3627, 3628, 3682, 3683, 3685, 3686, 3687, 3688, 3689, 3690, 3719)

3632. Khutsky, G. I., Problems of stage interaction in impulse steam turbines (in Russian), *Sb. Nauchn. Rabot Belorussk. Politekhn. In-ta* no. 67, 9-25, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9756.

Results are presented of researches on an experimental air turbine. The fundamental loss factors associated with inhomogeneity of the velocity field behind a turbine stage are the losses in smoothing the flow. For steam turbine stages with unwarped blades, these losses represent 4-12% of the quantity of kinetic energy behind the rotor. The velocity and pressure distributions over the blade depth in the interstage clearance spaces are fundamentally influenced by the preceding stage. Author recommends the selection of the coefficient of utilization of the kinetic energy for intermediate stages of the impulse type, (μ = 0.75-1.0, the magnitude whereof is determined by the magnitude of the loss on smoothing the flow and vortex losses in the peripheral clearances.

Regenerative losses from the flow section of the turbine of the order of 3.8% do not influence the coefficient of utilization of kinetic energy μ.

A. I. Loshkarev

Courtesy Referativnyi Zhurnal, USSR

3633. Vasiliev, L. G., Determination of the flow capacity of a two-dimensional turbine blade cascade (in Russian), *Sudostroenie* no. 9, 24-31, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9726.

Author investigates the flow volume through a two-dimensional turbine blade cascade for different pressure gradients.

At subcritical speeds, the back of the profile following the constriction has a flow with a positive pressure gradient, the velocity field in the neck section of the duct is irregular, and the mean speed in the constriction is higher than the speed at the outlet of the cascade. Introducing a coefficient A, representing the ratio of the flow volume of an ideal gas through one duct of a two-dimensional blade cascade with trailing edges of infinite thinness, to the flow volume of an ideal gas through a unidimensional duct with the same cross-sectional area in the constriction, it can be represented in obvious form by the velocity at the trailing edge and at the discharge, the ratio of the speed at the back of the blade in the constriction and the speed at the trailing edge m; it is assumed that the velocities in the constriction are distributed hyperbolically with reference to the radius of curvature of the streamline. The flow volume through the two-dimensional cascade will be greater than through a unidimensional duct with the same cross-sectional area in the constriction for subcritical pressure gradients ($A \geqslant 1.0$).

The value of the coefficient A will be affected by compressibility at value of $M \geqslant 0.6$, therefore with $m \leqslant 1.1$ the coefficient A can be determined for the flow conditions of an incompressible fluid. Charts are given showing the dependence of coefficient A on the cascade spacing for a range of profile forms. Variation in

the angle of the incident flow on the cascade has no influence on the value of the coefficient A, within limits of 70°–100°.

In determining the value of the maximum flow volume it can be reckoned that the constricted cross section of the duct will appear as the critical cross section (error < 0.5%). The maximum flow volume through the two-dimensional cascade in the presence of diffusion on the back of the profile in the region of the constriction and oblique transition is obtained with a pressure gradient below the critical. A. I. Loshkarev

Courtesy Referativnyi Zhurnal, USSR

3634. **Elizarov, V. S., The calculation of profile losses in the blade cascades of marine steam turbines, with edges of finite thickness** (in Russian), *Sudostroeinie* no. 8, 24–29, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9722.

The results of theoretical and experimental investigations into profile losses are presented with account of the effect of the thickness of the trailing edge at subsonic velocities. It is suggested that the amount of edge losses must be conditioned by the finite thickness of the blade edge as well as by the thickness of the boundary layers on the convex and concave sides of the profile at the trailing edge. Experimentally, the thicknesses of the boundary layer have been determined at a distance from the cascade, and at the trailing edges of the profiles.

Guide blade cascades with profiles of type C-2, and rotor cascades of profiles A-20 and A-27/24 were investigated. Each selected cascade was tested at different angles of incidence of the oncoming flow and varying blade spacing. The change in thickness of the trailing edges was effected by shifting the concave surface, relative to the convex, along the normal to profile chord. The change in profile outline and the adjacent blade ducts has been disregarded by the author.

Measurement of the full head in the cross sections of the boundary layers and the aerodynamic wake was done by microstatic tubes, flattened at the inflow and end. The outside dimensions of the microstatic tubes were 0.2 ± 1.9 mm, and the inside dimensions of the intake aperture, 0.12 × 1.1 mm. The microtube for static pressure, used for measurements of aerodynamic wake flow, had an external diameter of 0.7 mm. Static pressure on the outline of the profile was measured through bores in the central section.

In conclusion, an account is given of the method of determining profile losses in a cascade with trailing edges of finite thickness. The author quotes an example showing that calculation by his method gives an error in determining cascade efficiency not exceeding 0.4%. L. V. Knyazev

Courtesy Referativnyi Zhurnal, USSR

3635. **Asanuma, T., and Sawa, N., On the ineffective lift of poppet valves in internal combustion engines,** *Bull. JSME* **2**, 7, 417–422, Aug. 1959.

Report gives empirical data obtained under well-instrumented laboratory conditions on one-cylinder-and-valve configuration. Effects of speed, pressure drop, cam overlap and piston dead space shape on the ineffective part of the valve action are presented by studying both the air flow through the combustion chamber and oscillograph records of the internal pressure variations.

Referring the phenomena to the valve lift rather than to the corresponding crank angle simplifies greatly the reporting of the data. Reviewer feels that the data are quantitatively valid only for configurations very close in size and disposition to the apparatus used in these experiments. Also the intermittent motion-gas inertia approach to the problem has been neglected in this study. B. Posniak, USA

3636. **Curren, A. N., Price, H. G., Jr., and Douglass, H. W., Analysis of effects of rocket-engine design parameters on regenerative-cooling capabilities of several propellants,** NASA TN D-66, 47 pp., Sept. 1959.

Authors conducted an analytical study of heat transfer in regeneratively cooled, cylindrical rocket engines with axial coolant flow. In each phase of the problem, well-known relations developed for turbulent pipe flow were employed, with suitable modification for the high temperature flow fields encountered in the engines. Calculations for convective heat transfer to the wall, conduction through the wall, and convective heat transfer to the cooling fluid were carried out on a digital computer at several axial positions in the chamber and nozzle at thrust levels of 10^3, 10^4, 10^5, and 10^6 pounds for the following propellant combinations: hydrogen-fluorine, hydrogen-oxygen, hydrazine-fluorine, ammonia-fluorine, and jet engine fuel (JP4)-oxygen. In some cases ceramic liners were considered. The parameters studied, listed in approximate order of decreasing influence on cooling, are engine size, performance efficiency, fuel-oxidant mixture ratio, expansion area ratio, combustion chamber pressure, and contraction area ratio. The results indicate the parametric ranges in which regenerative cooling is feasible for the given propellant combinations.

T. C. Adamson, Jr., USA

3637. **Wintucky, W. T., Analytical comparison of hydrazine with primary propellants as the turbine drive fluid for hydrogen-fluorine and hydrogen-oxygen altitude stage rockets,** NASA TN D-78, 26 pp., Oct. 1959.

Primary propellants, hydrogen-fluorine and hydrogen-oxygen, were compared with a high-energy monopropellant, hydrazine, as the turbine drive fluid for two high-energy-rocket altitude stages of 20,000 pounds nominal thrust. The effect of the two turbine drive systems on the payload was compared over a range of missions. The use of the monopropellant turbine drive system caused a penalty in stage payload of 45 to 65 pounds for the hydrogen-fluorine stage and 75 to 95 pounds for the hydrogen-oxygen stage. Thus, except for extreme missions where the payload itself becomes small, the monopropellant system is sufficiently competitive to the bleed system that its advantages, from a control and starting standpoint, might make the monopropellant system more desirable.

From author's summary by L. S. Dzung, Switzerland

3638. **Dugger, G. L., Recent advances in ramjet combustion,** *ARS J.* **29**, 11, 819–827, Nov. 1959.

This paper is an excellent review of the status and potential of ramjet propulsion. It presents an objective evaluation of the principal combustion problems, and the prospects and techniques for overcoming them. The paper makes a convincing argument for ramjet propulsion in cruise vehicles in the speed range Mach 4 to Mach 8. An extensive list of references includes several earlier review papers. E. W. Price, USA

3639. **Stein, S., A high-performance 250-pound-thrust rocket engine utilizing coaxial-flow injection of JP-4 fuel and liquid oxygen,** NASA TN D-126, 14 pp., Oct. 1959.

Small, compact rocket engines with a high degree of reliability for continual operation were developed for wind-tunnel missile and space-vehicle-booster models. These engines have design features permitting inexpensive and easy fabrication of injectors and combustors for acceleration of research programs.

These engines had high performance that was principally due to a novel means of atomizing liquid fuel by minimizing the mass mean drop size through the mechanism of thin annular streams surrounding the oxidant. From author's summary

3640. **Price, E. W., Combustion instability in solid propellant rocket motors** (in English), *Astronaut. Acta* **5**, 1, 63–72, 1959.

The phenomenon of combustion instability in rocket motors is an oscillatory interaction between gas flow and combustion of the propellant in such a way that pressure oscillations with frequencies of 500 to 50,000 cy/sec develop with peak-to-peak amplitudes comparable to the mean pressure. A qualitative description

is presented of the phenomenon; difficulties of experimental study are discussed and mechanisms of excitation and suppression of instability are described. From author's summary

Magneto-fluid-dynamics

(See also Revs. 3562, 3684)

3641. Yen, K. T., Incompressible wedge flows of an electrically conducting viscous fluid in the presence of a magnetic field, *J. Aero/Space Sci.* **27,** 1, 74–75 (Readers' Forum), Jan. 1960.

Note gives the ordinary differential equations and boundary conditions governing the similarity solutions in which the stream function and the magnetic stream function are proportional to the same power of the distance x. Further work will be reported later.

W.-H. Chu, USA

3642. Velikhov, E. P., Stability of a plane Poiseuille flow of an ideally conducting fluid in a longitudinal magnetic field, *Soviet Phys.-JETP* **9,** 4, 848–855, Oct. 1959. (Translation of *Zh. Eksp. Teor. Fiz.* **36,** 1192–1202, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.).

Author investigates stability of the laminar flow of an incompressible ideally conducting fluid in a longitudinal magnetic field with respect to infinitesimally small disturbances. The well-known method of Heisenberg and Lin is used. The motion of the fluid is described by the Navier-Stokes equation (with the electromagnetic force added) and the set of Maxwell's equations. The character of the flow is determined by three parameters: hydrodynamic Reynolds number, magnetic Reynolds number, and Alfvên number. At the critical values of these parameters the flow becomes unstable. Velocity, pressure, and magnetic field are represented as sums of large stationary values and small disturbing increments. Velocity is assumed to be parallel to x-axis and all quantities depend only on z-coordinate. Since the most critical are two-dimentional disturbances, only these are considered, leading to a sixth-order differential equation for the z-component of the disturbance of the magnetic field. The z-component of the velocity is connected with the z-component of the magnetic field, hence the boundary conditions are superimposed upon the velocity. The problem reduces to determination of eigenvalues of frequency of the disturbances. The sufficient condition for the stability of flow is that the Alfvên number must be positive. After lengthy calculations author obtains asymptotic expression for the linearly independent solutions of the equation. The next problems discussed are: stability of plane flow for the infinite Reynolds number and Poiseuille flow by numerical method. The obtained conditions refer to Alfvên number (as above) and to characteristic induction of magnetic field.

M. Z. v. Krzywoblocki, USA

3643. Peschka, W., Contribution to the vortex laws in magnetohydrodynamics (in German), *Öst. Ing.-Arch.* **13,** 1, 17–23, May 1959.

The vortex laws of Bjerkness and L. Crocco are generalized for magnetohydrodynamics. Further, two integrals of the magnetohydrodynamic equations are given for the case of an incompressible fluid with infinite conductivity. One corresponds to a solution of the Bernoulli equation of hydrodynamics and the other to the Kármán vortex street. Neither solution, however, has the significance which it has in hydrodynamics.

From author's summary by S. Ostrach, USA

3644. Ludford, G. S. S., Rayleigh's problem in hydromagnetics: The impulsive motion of a pole-piece (in English), *Arch. Rational Mech. Anal.* **3,** 1, 14–27, Mar. 1959.

Author considers the motion of an incompressible viscous (ν = kinematic viscosity) electrically conducting fluid contained between the parallel, plane pole-pieces ($y = 0$, $y = b$) of a permanent magnet (η = magnetic diffusivity), which provides a uniform external field in the y-direction. Starting at the time $t = 0$ with the fluid at rest, the magnet is made to move uniformly in the negative x-direction. The limiting case of zero conductivity and infinite separation ($b = \infty$) was considered by Rayleigh. The object of this paper is to give a simple exact solution for which the transition from zero to infinite conductivity can be traced and the modifying effects of viscosity determined. The solution is obtained by the Laplace transform. The case of the infinite separation with $\nu = \eta$ and the general case with ν and η small but comparable, are successively considered. Asymptotic behavior and shearing stress at a pole-piece are calculated.

From author's summary by G. Sestini, Italy

3645. Jungclaus, G., Laminar boundary layers in magnetohydrodynamics (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 85, 25 pp., Mar. 1959.

Laminar boundary layers are treated in incompressible and electrically conducting liquids under the influence of magnetic fields. The pressure normal to the boundary layer is taken as constant so that the usual boundary-layer theory is applicable. A very simple solution is given for strong magnetic fields. The conditions are given for similarity solutions for arbitrary strength of the magnetic field. Some of these solutions are also presented.

From author's summary by T. P. Torda, USA

3646. Akhiezer, A. I., Liubarskii, G. Ia., Polovin, R. V., Simple waves in magnetohydrodynamics (in Ukrainian), *Ukrain. Fiz. Zh.* **3,** 4, 433–438, 1958. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. A-139, 6 pp.)

Authors sketch a general theory of simple waves, analogous to nonlinear expansion waves in gasdynamics, for n equations of the form

$$\sum_{k=1}^{n} X_{ik}(u)\frac{\partial u_k}{\partial x} + T_{ik}(u)\frac{\partial u_k}{\partial t} = 0 \qquad i = 1, 2, \ldots n$$

by looking for solutions of the form $u_k = u_k(u_1)$, $u_1 = u_1(x, t)$. It is shown in general how the simple waves are constructed as an integration over linearized waves. Application is outlined for all the forms of magnetohydrodynamic waves, Alfvên waves, magnetoacoustic waves, and entropy waves. Finally it is proved that a constant flow region of (x, t) can only be bounded by a shock wave or simple wave. Practical determination of the unknown functions is not carried out. Similar results have appeared in various papers, especially those of Friedrichs.

J. D. Cole, USA

3647. Sears, W. R., Magnetohydrodynamic effects in aerodynamic flows, *ARS J.* **29,** 6, 397–406, June 1959.

Reviewer feel that this is an excellent introduction to the theory of magnetohydrodynamics, with particular reference to the effects of interest to aeronautical engineers. A brief survey of possible practical applications, and a good bibliography are included.

D. W. Holder, England

3648. Kaplan, S. A., and Kolodiy, B. I., The functional equations of magneto-hydrodynamics (in Ukrainian), *Dopoviditа Povidomleniya, Lvovsk. In-ta* no. 7, 229–230, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10020.

Using the method of E. Hopf [*J. Rational Mech. Analysis* **1,** p. 87, 1952], a functional equation is obtained, describing magnetohydrodynamic turbulence in an incompressible fluid.

A. G. Kulikovskii
Courtesy Referativnyi Zhurnal, USSR

3649. Kerrebrock, J. L., and Marble, F. E., Constant-temperature magneto-gasdynamic channel flow, *J. Aero/Space Sci.* **27**, 1, p. 78 (Readers' Forum), Jan. 1960.

It is found that for prescribed velocity field, electrical field and conductivity, the current can be calculated by integration. Work is related to analytic investigation of the boundary layer in a physically reasonable accelerator. W.-H. Chu, USA

3650. Gordeev, G. V., The influence of end boundaries upon the rotation of plasma in a magnetic field, *Soviet Phys.-Tech. Phys.* **4**, 6, 683–686, Dec. 1959 (Translation of *Zh. Tekh. Fiz. USSR* **29**, 6, 759–763, June 1959 by Amer. Inst. Phys., New York, N. Y.)

A plasma column in an axial magnetic field, through which a radial current flows, rotates about its axis under influence of electromagnetic forces in the cavity. Previous work by author [*Zh. Tekh. Fiz., USSR* **28**, 9, 1958] for infinite length columns showed speed of rotation may exceed velocity of light for certain values of magnetic field intensity, current strength and electrode radius. Present paper investigates effect of finite length. Equations for rotational velocity and current density are solved using Fourier analysis. For length of column greater than radius, author shows the correction in velocity due to end effects is small. For $L < R$, the correction is important, increasing as L decreases.

Mary F. Romig, USA

3651. Vedenov, A. A., and Larkin, A. I., Equation of state of a plasma, *Soviet Phys.-JETP* **9**, 4, 806–811, Oct. 1959. (Translation of *Zh. Eksp. Teor. Fiz.* **36**, 1133–1142, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.).

Authors consider the equation of state of plasma, i.e., the equation of state of a system of particles which interact via Coulomb forces. Since the Coulomb forces are long-range, even in the first term of an expansion of the thermodynamic quantities in powers of gas density, it is wrong to consider only binary interactions. Authors begin with the system of interacting particles in a state of thermodynamic equilibrium described in terms of the Hamiltonian. The gas is assumed to be nondegenerate so that deviations from the Boltzmann distribution are small. First they consider short-range forces with no-spin particles. To find the second virial coefficient it is necessary to sum all graphs which contain two solid lines which go in the upward direction and whose remaining lines go downward. Next problem considered is the summation of graphs in the case of Coulomb interaction; to obtain the result, authors had to introduce a sequence of simplifying assumptions. The last problem attacked is that of the equation of state of plasma. Authors consider a system consisting of ions and electrons. The first terms in the density expansion have been determined by means of a graphical method similar to that one used in quantum electrodynamics. The final equation expresses the free energy per unit volume and consists of three first terms of the expansion. To find the higher-order terms it is necessary to know the wave functions of three interacting Coulomb particles.

M. Z. v. Krzywoblocki, USA

Aeroelasticity

3652. Ichikawa, T., Aeroelastic instabilities of a slender wing-body combination (in Japanese), *J. Japan Soc. Aero. Space Sci.* **8**, 72, 1–6, Jan. 1960.

Aeroelastic instabilities of a slender wing-body combination are analyzed using Miles' unsteady aerodynamic theory on a slender-body configuration. For locating roots of the characteristic equation in the complex plane, root-locus method is employed, taking the speed of the slender body as a parameter. Following results are obtained. (1) Both dynamic and static aeroelastic instability can occur. (2) The dynamic instability is a coupled pitching and bending oscillation. (3) The static instability is caused by a loss of restoring moment due to body bending. (4) The dynamic instability does not occur if the wing is located aft of the first bending nodal point.

From author's summary by K. Washizu, Japan

3653. Broadbent, E. G., Flutter of an untapered wing allowing for thermal effects, Aero. Res. Counc. Lond. Curr. Pap. 442, 13 pp., 1959.

A thin rectangular solid steel wing of aspect ratio 3 is considered. A temperature difference of 133 F between the average of the leading and trailing edges and the mid chord, simulating acceleration to Mach 3 at 20,000-ft altitude, is assumed. Effect of thermal stresses in reducing torsional and bending stiffness and introducing chordwise bending as an accompaniment to spanwise bending is included. Flutter analysis is based on use of two normal coordinates, one for fundamental bending and the other for fundamental torsion (uncoupled because of symmetry), and piston theory. Flutter occurs at Mach 3.6 and is due entirely to aerodynamic coupling associated with chordwise bending. Root constraint is found not to be important. Increased thickness or use of hollow section would greatly reduce tendency to flutter. Reviewer considers paper to be of considerable significance in that it sheds light on a possibly important phenomenon.

G. Isakson, USA

3654. Khaskind, M. D., Vibrations of thin plane wings in tandem in plane incompressible flow, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 4, 649–658, 1958. (Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

This paper deals with small vibrations of thin plane wings arranged in tandem in plane incompressible flow. The solution is obtained by breaking the problem into two simpler ones. One of these problems is nonhomogeneous and represents noncirculatory flow past a system of wings, while the second is a homogeneous problem which can be solved by means of functional combinations containing several constants. Thin-wing theory is used to solve these problems, the whole investigation consisting essentially of finding the constants by means of linear equations.

Closer attention is given to the problem of vibrations in a tandem biplane system in which one of the wings is fixed. Approximate expressions are given for the hydrodynamic forces and the energy characteristics of the system, regarded as a moving group.

From author's summary by H. T. Schlichting, Germany

3655. Wilts, C. H., Incompressible flutter characteristics of representative aircraft wings, NACA Rep. 1390, 38 pp., 1958.

See AMR **10**(1957), Rev. 3745.

3656. Ikeda, K., On the body divergence of rockets (in Japanese), *J. Japan Soc. Aero. Space Sci.* **7**, 70, 296–299, Nov. 1959.

Body divergence is a phenomenon of longitudinal aeroelastic instability of a flying slender body. In the present analysis, aerodynamic forces acting on the body are roughly represented by concentrated loads near the nose and tail, and a formula for obtaining the critical divergence speed is given.

From author's summary by K. Washizu, Japan

3657. Bennett, F. V., and Yntema, R. T., Evaluation of several approximate methods for calculating the symmetrical bending-moment response of flexible airplanes to isotropic atmospheric turbulence, NASA Memo 2-18-59L, 57 pp., Mar. 1959.

To investigate the usefulness of several approximate procedures for calculating the bending-moment response of flexible airplanes to continuous isotropic turbulence, the output power spectra of the wing bending moments for a simplified airplane, consisting of a uniform beam with a concentrated fuselage mass, are calculated.

The airplane motions are vertical rigid-body translation and symmetric wing bending. Aerodynamic forces are based on strip theory and include the unsteady lift effects due to gust velocity and wing velocity.

Comparison of output power spectra of wing-bending moments obtained by several approximate methods with those based on exact transfer functions leads to: (a) the force-summation method, using one natural bending mode and the matrix method, based on five stations across the semispan, gives very good results; (b) the mode-displacement method based on a natural mode yields inaccurate results; (c) the force-summation method based on an approximate parabolic mode and a natural frequency calculated by Rayleigh method gives good results, except that the approximated natural frequency causes a shift in the fundamental mode resonant peak; (d) if the natural frequency is known, the force-summation method based on an approximate parabolic mode has sufficient accuracy.

Calculations with one-dimensional and two-dimensional gusts do show that spanwise variations of turbulence result in a decreased response, except when the ratio of fuselage mass to total mass is small. H. Bergh, Holland

3658. Shufflebarger, C. C., Payne, C. B., and Cohen, G. L., A correlation of results of a flight investigation with results of an analytical study of effects of wing flexibility on wing strains due to gusts, NACA Rep. 1365, 14 pp., 1958.

See AMR **11**(1958), Rev. 1070.

Aeronautics

(See also Revs. 3240, 3281, 3283, 3361, 3545, 3598, 3638, 3653, 3694)

3659. Templin, R. J., Note on the minimum power required for flight at low airspeeds, Nat. Res. Counc., Canada, Aero Rep. LR-245, 24 pp., May 1959.

Report uses the change in momentum components between jet or deflected slip stream and free stream to derive nondimensional performance coefficients. The ratio of power required to the hover power for VTOL, STOL and Transitional Flight Regimes is presented as a function of jet-to-flight-velocity ratio, for variations in wing lift. The minimum-power-required ratio corresponds to a particular jet exhaust angle and related lift coefficient and is shown to be a function of the effective span loading. Minimum power required decreases as the flight speed increases. Report indicates continuing interest of Canadian Research Establishments in general and comparative studies of the various VTOL-type vehicles. R. L. Leutzinger, USA

3660. Mottard, E. J., A brief investigation of the effect of waves on the take-off resistance of a seaplane, NASA TN D-165, 17 pp., Dec. 1959.

The take-off resistance of a model of a seaplane with a length-beam ratio of 15 and a wing loading of 120 pounds per square foot was determined in smooth water and in waves of three heights under various conditions of load, speed, elevator setting, angle of dead rise, and center-of-gravity position. In general, the resistance was greater in waves than in smooth water and increased with wave height. The maximum increase due to waves occurred at speeds between hump speed and take-off. In 6-ft waves the maximum increase was 65% at a speed equal to 70% of getaway speed. The effect of waves on resistance was about the same for dead-rise angles of 20°, 40°, and 60°.

From author's summary

3661. Stewart, W., Helicopter behaviour in the vortex-ring conditions, Aero. Res. Counc. Lond. Rep. Mem. 3117, 10 pp., 1959.

A region of roughness, associated with the airflow conditions of the vortex-ring state, occurs when a helicopter is operating in vertical or near vertical descents in the range of about 500 and 1500 ft/min. The turbulent circulating air and the rapid changes in local velocities in this flow pattern can cause serious helicopter handling difficulties. This could cause concern in a slow steep approach, particularly under instrument-flying conditions.

This report describes flight experience in the vortex-ring conditions with the *Sikorsky* R-4B, R-6 and S-51, *Bell* 47 and *Bristol* 171 helicopters. It is shown that the helicopter behavior varies from a mild wallowing on the best type to a complete loss of control on the worst case. These effects are due to the turbulent-flow changes in the vortex ring and the loss of control is thought to be caused by large changes in pitching moments on the fuselage with small displacements of the helicopter relative to the unusual flow pattern. From author's summary

3662. Thomas, L. P., III, A flight study of the conversion maneuver of a tilt-wing VTOL aircraft, NASA TN D-153, 11 pp., Dec. 1959.

Astronautics

(See also Revs. 3234, 3273, 3276, 3277, 3278, 3280, 3281, 3282, 3526, 3552, 3597, 3599, 3602, 3637, 3651, 3656, 3746)

3663. Baker, R. M. L., Jr., Accuracy required for a return from interplanetary voyages, *J. Brit. Interplanetary Soc.* **17,** 3/4, 93-98, May/June-July/Aug. 1959.

Landing on a planet with braking in the atmosphere calls for surprising navigational accuracy. General discussion and some computations are presented. Vehicle is assumed to have sectional density of 5 g/cm^3 (corresponding to drag canopy or balloon), and no heat sink, ablation, solar or lunar interference is considered. A vehicle landing on the Earth and having at infinity the speed of 0.316 of the surface-circular-satellite speed must aim, at infinity, at a circular annulus of the radius of 4.5 Earth radii, and of the thickness of $3dr_0$, where dr_0 is the permissible variation in the altitude of the perigee in the absence of drag. If aimed outside this annulus, the vehicle will escape the Earth in a hyperbolic trajectory; if aimed inside, it would collide, or at best burn up in atmosphere. An estimate of dr_0 is attempted for a parabolic trajectory (one having zero velocity at infinity, where the radius of the annulus approached infinity).

It is shown that the perigee altitude on first pass must lie between 108 km (this removes 1.5% of vehicle's energy and converts parabola into ellipse with semimajor axis of no more than 32.2 Earth radii) and 105 km (semimajor axis of 11.5 Earth radii, but maximum temperature of 1000 K being reached). From this the author deduces that the thickness of the 4.64 Earth radii annulus would be only 7 km. Obviously, though, a vehicle approaching the Earth on a hyperbolic trajectory would be even more sensitive to the altitude of the perigee, and, with a certain velocity at infinity, landing without retro-rockets will be impossible. Use of relatively small retro-rockets to steer the vehicle into the desired level by adjustment of its speed just before (and again after) the first perigee is briefly discussed.

It seems to this reviewer, however, that the more imperative use of small rockets would be to be fired crosswise long before the first pass. Since this would have to be done on the hyperbolic approach (and the obvious minimum margin of power is to save a vehicle aimed at the center of Earth) the necessary problems of control seem indeed formidable. Most of the braking occurs in the levels in the transitional and slip flow; the regime near perigee, in which the surface temperature limits the penetration into the atmosphere, contributes only a small fraction of the total braking action. Little reliance is placed on lift in the high altitudes.

S. J. Zaroodny, USA

3664. Brunk, W. E., and Flaherty, R. J., Methods and velocity requirements for the rendezvous of satellites in circumplanetary orbits, NASA TN D-81, 42 pp., Oct. 1959.

Paper contains a parameter study for velocity and flight time required to transfer from earth surface to orbiting satellite (direct rendezvous) and from vehicle already in orbit to orbiting satellite (orbital rendezvous). Simplifying assumptions include (1) no atmosphere, (2) inverse-square, central force field, (3) no guidance error allowance, (4) impulsive thrust, (5) velocity increment close to minimum. Effect of earth's oblateness on rendezvous is also discussed. J. Lorell, USA

3665. Battin, R. H., The determination of round-trip planetary reconnaissance trajectories, *J. Aero/Space Sci.* **26,** 9, 545-567, Sept. 1959.

As background material author defines conic sections, derives their principal geometrical properties, and discusses their use in trajectory computation. Planetary reconnaissance is then treated analytically at two levels of complexity. The first involves idealized solar system having circular coplanar orbits. Second, elliptical, inclined orbits are considered. Higher energy trajectories are treated as well as the Hohmann transfer ellipse. Unpowered round trip to Mars is worked out numerically.

In comparing models author notes that while former is fairly adequate as regards point where trajectory intercepts Mars' orbit and time required, latter is required for determining effect of Mars on local portion of trajectory as well as return trip. Reviewer considers that because of approximation employed, particularly as regards the perturbing effect of Mars, even the three-dimensional model is too crude for practical treatment of an unpowered round trip intended to impact earth upon return. However, method should prove of value to determine approximate initial conditions as starting point for step-by-step integration of equations of motion in large digital computer. S. B. Batdorf, USA

3666. Loh, W. H. T., Minor circle flight for orbital launched or boost-glide vehicles, *ARS J.* **29,** 10, 789-791 (Tech. Notes), Oct. 1959.

3667. Vinti, J. P., A new method of solution for unretarded satellite orbits, AFOSR TN 59-608 (Nat. Bur. Stands. Rep. 6449; ASTIA AD 217 395), 23 pp., July 1959.

The effect of the oblateness of a planet on the orbit of any satellite is studied. An axially symmetric solution V_L of Laplace's equation in oblate spheroidal coordinates, leading to exact separability of the Hamilton-Jacobi equation for the motion of a satellite, is given. The solution V_L which is the gravitational potential about an oblate planet can be expressed by means of an expansion in spherical harmonics. The harmonics are adjustable to make the potential close to the actual potential accepted for earth. The problem of satellite motion reduces to quadratures. Author shows the perturbation theory is not necessary to the accurate theory of orbits for unretarded satellites.

N. E. Cristescu, Roumania

3668. Klein, H., Some notes on dynamics of trajectories, Douglas Aircr. Co. Rep. SM-23288, 275 pp., Mar. 1959.

A compilation of lecture notes covering introductory aspects of space-flight mechanics and propulsion dynamics. The material is well augmented by numerous supplementary diagrams, graphs and tables, while an appendix presents problems related to the subject material of each chapter. Its chief appeal would seem to be to the non-specialist engineer or the university undergraduate, as well as to the teacher of astronautics or mechanics.

S. E. Ross, USA

3669. Carton, D. S., Minimum propulsion for soft moon landing of instruments, Coll. Aero. Cranfield, Rep. 94, 38 pp., July 1959.

Vehicle requirements for effecting a soft landing on the moon are estimated, based on a collision-course trajectory and optimized vehicle design studies employing component performance estimates for propulsion system and structure which are approximately representative of current technology. A 240-lb landing vehicle is required to soft-land 100 lb of payload, requiring 250,000 to 350,000 lb gross weight at earth take-off.

P. Sandorff, USA

3670. Williams, R. S., The Martin-Denver rocket-missile testing facilities, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-7, 11 pp.

3671. Fiedler, W. A., The launching of large missiles (in English), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1958, 249-254.

Fundamental considerations of the surface launch problems of large missiles include requirements concerning performance, dynamics and strength, the specific requirements to the launcher and to the thrust-rocket system and further the interaction of these systems.

Various design approaches are feasible, as shown by typical new examples. The sometimes contradictory requirements were especially well combined in the Induced Pitch Launching System. Theory of motion and practical considerations of this recently tested system are discussed. From author's summary

3672. Horsfall, R. B., Celestial guidance, *ARS J.* **29,** 12, 981-988, Dec. 1959.

3673. Newton, R. R., Method of stabilizing an astronomical satellite, *ARS J.* **29,** 9, 665-666 (Tech. Notes), Sept. 1959.

3674. Moncrieff-Yeates, A. J., Some elementary considerations concerning fringe of space environmental conditions, *Aero/Space Engng.* **18,** 12, 32-35, Dec. 1959.

3675. Nonweiler, T. R. F., Aerodynamic problems of manned space vehicles, *J. Roy. Aero. Soc.* **63,** 585, 521-528, Sept. 1959.

3676. Benton, Mildred, compiled by, The literature of space science and exploration, U. S. Nav. Res. Lab. Bibliography no. 13 (PB 131 755), 264 pp., Sept. 1958.

Book—3677. Hecht, F., edited by, IXth International Astronautical Congress Proceedings, Amsterdam, Holland, 1958, Vols. 1 and 2; Wien, Springer-Verlag, 1959, xii + 970 pp. $49.50. (Revs. 3677-3704)

Most of the 74 papers are of scientific importance as is to be expected from the impressive list of 93 authors. Evidently the wish for international cooperation and exchange of information prevailed; however, it is still wishful thinking and only a slow but significant start. Imbalance in the number of contributions from 14 countries shows the imbalance in the number of large long-range projects undertaken by the countries. At present, only two nations can afford the expensive hardware; all others are limited to advancement of theory. The full and necessary contribution of the latter to astronautics can only come from real world cooperation. Fifty-three authors from the U.S., 6 from France, 6 from Germany, 5 from Italy, 4 or less from Holland, Austria, USSR, Switzerland, Poland, Israel, England, North Ireland, Belgium, and Bulgaria contributed to most fields in the space efforts, including the aeromedical and space-biological field, but space law is omitted (a special meeting of delegates was held on this subject) and, rather surprisingly, no comprehensive study on progress in materials of construction is presented.

A table of contents, followed by an alphabetical list of authors, shows the following categories: I General astronautics; II Upper

atmosphere research; III Physics of space flight; IV Astronautical engineering; V Propulsion; VI Artificial satellites; VII Space biology. The latter group is not considered here because it is not of AMR interest.

Reviewer notices two trends. On one hand, many papers are of a highly speculative nature, dealing with velocities far beyond possible realization in the forseeable future; with application of propulsion methods for which even the theoretical basis has not been clearly established or laboratory results are not available; with flight in translunar and intersidereal space; but far-reaching imagination is necessary to lead exploration and development in the right direction in the rapidly expanding astrophysical sciences and technology. On the other hand, factual data on the Explorers, their carrier rockets, instrumentation, operation, scientific objectives and results are given by the USA in greater detail than ever before; dynamic effects of the motion, optical observations, and upper atmosphere exploration of three Sputniks are presented by the USSR for the first time. All these are marvelously prepared papers, although the USSR contributions treat more secondary topics than the complete overall systems. Forty per cent of the papers deal with propulsion systems, such as interstellar gas, chemical, ion, plasma, solar, arc-heated, electrostatic, mixing and magneto-hydrodynamic methods (von Kármán proposes the word "magnetofluidmechanics"), and with the reentry problem. Studies on relativity, the planet Mars, ecospheric planets, the radiation belt, the *n*-body problem, navigation and guidance systems are significant. However, this enumeration is by no means complete. A paper by Koelle gives an almost complete set of references in the field of orbital techniques, covering 35 pages.

The Proceedings give the titles and abstracts in English, German, and French, thus permitting the specialist to find the papers of greatest interest for him without difficulty, the full texts are printed in the language in which they were presented. Only Sedov's outstanding paper is given both in Russian and in full English translation.

The papers of interest to AMR readers are listed here. Many of them in reviewer's opinion show keen insight and progressive thought. G. R. Graetzer, USA

3678. **Gadomski, J., Five types of ecospheric planets** (in German), 2, 785–793.

3679. **Cap, F., Applications of the Groebner method for the solution of differential equations of the *n*-body problem** (in German), 1, 62–66.
See AMR 12 (1959), Rev. 1571.

3680. **Cap, F., Relativity theory and astronautics** (in German), 1, 209–221.

3681. **Gravalos, F. G., Edelfelt, I. H., and Emmons, H. W., The supersonic flow about a blunt body of revolution for gases at chemical equilibrium** (in English), 1, 312–332.

3682. **Corbeau, J., and Diot, C., Theoretical study of the combustion of propellant droplets in a rocket motor combustion chamber** (in French), 2, 526–556.

3683. **Vandenkerckhove, J. A., Note on the optimum design of solid propellant power-plants for missiles systems engineering** (in English), 1, 148–167.

3684. **Napolitano, L. G., Magneto-fluid-dynamics of two interacting streams** (in English), 2, 570–602.

3685. **Shepherd, L. R., Electrical propulsion systems in space flight** (in English), 2, 932–945.

3686. **Sanger-Bredt, Irene, Concerning working fluids for unconventionally heated rocket engines** (in English), 2, 885–903.

3687. **Sanger, E., Sources of radiation for photonic jet propulsion** (in German), 2, 817–827.

3688. **Stuhlinger, E., Advanced propulsion systems for space vehicles** (in English), 1, 232–242.

3689. **Ostinelli, E., Limit performances of ion propulsion of space ships employing fission power of uranium nuclei or fusion power of deuterium nuclei** (in Italian), 1, 380–393.

3690. **Wolczek, O. S., Artificial nuclear energy sources in cosmic space** (in German), 1, 67–87.

3691. **Hermann, R., Problems of hypersonic flight at the reentry of satellite vehicles** (in English), 2, 764–784.

3692. **Nonweiler, T., The motion of an earth satellite on reentry to the atmosphere** (in English), 2, 842–864.

3693. **Singer, S. F., Scientific problems in cislunar space and their exploration with rocket vehicles** (in English), 2, 904–913.

3694. **Miele, A., General variational theory of the flight paths of rocket-powered aircraft, missiles, and satellite carriers** (in English), 2, 946–970.

3695. **Magness, T. A., McGuire, J. B., and Smith, O. K., Accuracy requirements for interplanetary ballistic trajectories** (in English), 1, 286–306.

3696. **Schutte, K., The influence of the precision of the velocity vector on nearly circular orbits of artificial satellites** (in German), 1, 200–208.

3697. **Koelle, H. H., On the development of orbital techniques—a classification of orbital carriers and satellite vehicles** (in English), 2, 702–746.

3698. **Kooy, J. M. J., On the orbital computations and the guidance problem in a deep space rocket** (in English), 1, 469–506.

3699. **Merson, R. H., Techniques of analyzing terrestrial radio and optical observations of earth satellites** (in English), 2, 828–841.

3700. **Moeckel, W. E., Interplanetary trajectories with excess energy** (in English), 1, 96–119.

3701. **Krassovsky, V. I., Exploration of the upper atmosphere by the help of the third Soviet Sputnik** (in English), 2, 614–625.

3702. **Sedov, L. I., Dynamic effects on the motion of earth Sputniks** (in Russian and English), 1, 456–468.

3703. **Hibbs, A. R., Scientific results from the Explorer satellites** (in English), 2, 680–691.

3704. **von Braun, W., The Explorers** (in English), 2, 914–931.

End of symposium

Ballistics, Explosions

(See also Revs. 3363, 3668, 3709)

3705. Borg, S. F., A similarity solution for a blast in free space, *J. Franklin Inst.* **268,** 6, 446–452, Dec. 1959.

Similarity solution of hydrodynamic equations, spherical symmetry, constant γ, for constant mass of material expanding against an external pressure proportional to $(\text{time})^{-6\gamma/(3\gamma-1)}$.

J. Corner, England

3706. Zel'dovich, Ya. B., Converging cylindrical detonation wave, *Soviet Phys.-JETP* **9,** 3, 550–557, Sept. 1959. (Translation of *Zh. Eksp. Teor. Fiz.* **36,** 782–792, Mar. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The properties of detonation waves close to the normal detonation wave are considered. A theory is set up for the amplification of cylindrical converging detonation waves, which describes exactly the amplification in the initial stages of the process. By comparison with numerical calculations it is shown that the theory remains satisfactory even for small radii and appreciable amplification of the wave.

From author's summary by A. K. Oppenheim, USA

3707. Predvoditelev, A. S., Concerning spin detonation, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 760–765.

Purpose of the paper is to explain spin detonation in gases in terms of helical flow in a tube. Author develops the equations for helical flow, describing the flow as a central core rotating almost like a rigid body as it moves axially forward, surrounded by a turbulent region of transition to zero flow at the wall. The observed behavior of spinning detonation is described in terms of the rotation about the axis of a nearly plane detonation front tilted to the axis.

It is, however, generally agreed that spinning detonation cannot be associated with such helical flow, because angular momentum is not conserved. The uniform flow coming into the detonation front has zero angular momentum while Predvoditelev's outgoing flow has angular momentum, though only opposing torques at the wall are applied.

Marjorie W. Evans, USA

3708. Kapur, J. N., The evaluation of the co-volume function in Goldie's method of internal ballistics (in English), *J. Sci. Engng. Res.* **1,** 1, 124–130, Jan. 1957.

The co-volume function

$$G(f) = \Phi_0 + \frac{I_2^2}{\theta_1 (1-\epsilon)} \int_0^{\mu} \left[1 - \frac{2\theta_{\mu}}{\theta_1 (1-\epsilon)}\right] \frac{d\mu}{H}$$

given by Goldie (1945) can, for the case of zero shot-start pressure $[\Phi_0 = 0;\ f = 0;\ \epsilon = 0]$, be integrated to give an exact solution for this case and an approximation when Φ_0 is nonzero. Goldie believed that the approximation is most in error at $f = 0$, where the error may attain $\pm 10\%$.

Kapur (1956) showed that the above co-volume function can be expressed in terms of incomplete Beta functions when $\theta_1 = 0$ and in terms of incomplete Gamma functions when $\theta_1 = 1$. In this manner the error is smaller than by applying Goldie's approximation, where the order of error really may attain even -30%. Author analyzed the order of error at all burnt and at shot start and gives conclusions for different forms of powder and different values of θ and M.

J. D. Marinkovic, Yugoslavia

Acoustics

(See also Revs. 3272, 3348, 3530)

3709. Arase, T., Some characteristics of long-range explosive sound propagation, *J. Acoust. Soc. Amer.* **31,** 5, 588–595, May 1959.

This article deals with the propagation path, travel time, pressure levels, and spectrum levels of "leakage" arrivals. A brief discussion is given of sound propagation in ray-theory terminology. Experiments are described and their results analyzed by using plots of attenuation rate versus frequency, and spectrum level versus range. The results show that the "leakage" arrival is due to energy that in part travels in the surface channel and in part is refracted. The importance of these arrivals in increasing the range of sound propagation is mentioned.

G. A. Tokaty, R. L. Bowersox and H. W. Bergmann, England

3710. Sharma, S. K., Propagation of sound waves in visco-elastic compressible fluids (in English), *J. Sci. Engng. Res., India* **2,** 2, 253–258, July 1958.

Hydrodynamical equations for the propagation of sound waves in a viscoelastic compressible fluid are considered and their solutions obtained for (1) waves diverging from a spherical surface and (2) waves in a laterally unlimited medium. It has been shown that elasticity is a second-order effect, which does not affect the amplitude of the waves but increases the wave velocity.

G. S. Verma, USA

3711. Hovi, V., Velocity of sound at different temperatures in H_2, N_2, Air, O_2, and CO_2 (in English), *Annales Acad. Scient. Fennicae, Helsinki* (*A*) **6,** 18, 19 pp., 1959.

3712. Samuels, J. C., Reflection and refraction of elastic waves at the interface of two moving semi-infinite plane media, *J. Acoust. Soc. Amer.* **31,** 8, 1076–1079, Aug. 1959.

Author extends earlier work of others on acoustic case to elastic wave treatment. Two elastic media move with parallel velocities at an infinite plane interface. An elastic rotational or dilatational wave is incident such that the plane of incidence contains the velocity vectors of average motion. The formalism allows for a friction shear stress.

By straightforward procedures, author works out transmitted and reflected amplitudes of rotational and dilatational waves when either is incident. Conditions for total reflection in terms of incidence angle and speed of motion are derived, along with a "resonance" or instability condition for vanishing interface friction. This is compared with acoustic case.

This is the type of calculation which soon drops one in a sea of formulas. In the absence of suitable motivation (and possible applications of these results are not offered) such papers are hard going indeed.

R. Lyon, England

3713. Venzke, G., The sound absorption of porous foamed plastics (in German), *Acustica* **8,** 5, 295–300, 1958.

The frequency-dependence of the absorption coefficient of foamed plastics for perpendicular and diffuse incidence is investigated. By comparison with the theory for a porous substance with rigid skeleton, the foamed plastic appears to have a greater structure factor than most fibrous mats. Further it is shown how the elasticity of the skeleton and the provision of a skin-covering or perforations affect the frequency-dependence of the absorption.

From author's summary

3714. Kneser, H. O., and Roesler, H., The sound absorption in CO_2-Ar mixtures (in German), *Acustica* **9,** 1, 224–226, 1959.

Measurements of the sound absorption in CO_2-Ar mixtures up to 90% argon (at frequencies between 1 and 5 kc/s and pressures between 20 and 700 Torr) show an 8-fold increase in the CO_2 relaxation time. The relaxation velocity does not change in linear fashion with the argon concentration.

From authors' summary

3715. Dyer, I., Response of plates to a decaying and convecting random pressure field, *J. Acoust. Soc. Amer.* **31,** 7, 922–928, July 1959.

Author discusses vibration problem related to excitation of panels by flowing turbulence. Forcing field is described by mean flow speed and correlation time, plate response by damping and frequency parameters. He seeks to see how these interact and affect design of damping, etc.

Green's functions are used in bilinear expansion form. Correlation response of modes is solved for in general terms. Damping is taken to be a combination of hysteretic and viscous (or radiative). Turbulence has finite lifetime and average speed; correlation area is small compared to plate size. Response is studied for flow speeds far below and near (coincidence effect) the flexural wave speed. Special attention is paid to effectiveness of damping for slow mean flows. Any coincidence effect is governed by whether or not the eddy lasts an appreciable fraction of a wavelength.

R. Lyon, England

3716. Heckl, M., Sound radiation from a hollow cylinder excited by a sound source (in German), *Acustica* **9,** 2, 86–92, 1959.

As M. C. Junger first showed, the sound radiation from cylinders depends on the mode of vibration. It is necessary in calculating the power radiated from a cylinder excited by a point source to know the energy distribution among the different natural frequencies. Approximation formulas are given for calculating the radiation in many cases; also a formula for the mean square velocity is derived. From author's summary

3717. Grutzmacher, M., and Wesselhoft, E., The sound of a Chinese gong (in German), *Acustica* **9,** 1, 221–223, 1959.

The spectrum of a Chinese gong has been investigated. Because of the strong damping of higher partials, it is remarkably free from overtones. In contrast to a Gothic bell which has many overtones, all those with a nodal ring are missing from the gong.

From authors' summary

3718. Wilson, L. N., An experimental investigation of the noise generated by the turbulent flow around a rotating cylinder, AFOSR TN 59-487 (Univ. Toronto, Inst. Aerophys. Rep. 57; ASTIA AD 215 780), 73 pp., May 1959.

Useful paper considers noise radiated from turbulent boundary layer when surface does not vibrate, as discussed theoretically by reviewer [AMR **9** (1956), Rev. 1293] and Phillips [*Proc. Roy. Soc.* (*A*) **234**].

Spurious peaks in noise spectrum (at harmonics of cylinder speed) are corrected by correlation techniques in near field, but only intuitively in far field.

Author finds U^6 intensity law in far field, indicating dipole nature of radiated noise. In near field U^4 law holds, due to cancelling of contributions from different positions on surface. By estimating acoustic efficiency author concludes that noise from rigid wall is small in practical applications to aircraft.

N. Curle, England

3719. Coles, W. D., and Callaghan, E. E., Full-scale investigation of several jet-engine noise-reduction nozzles, NACA Rep. 1387, 23 pp., 1958.

See AMR **10** (1957), Rev. 3482.

3720. Kurbjun, M. C., Noise survey under static conditions of a turbine-driven transonic propeller with an advance ratio of 4.0, NASA Memo 4-18-59L, 14 pp., May 1959.

3721. Kuttruff, H., Optical model experiments of a stationary sound field; diffusivity in large rooms (in German), *Acustica* **8,** 5, 330–336, 1958.

The dependence of the diffusity of a stationary sound field in a room on the geometry and the reflective properties of the walls was studied for the case of very high frequencies, with an optical analog. Using a directional photocell the directional diffusity was measured in dependence on the ground plan, the position of the light source and the reflective properties of the walls. It follows that in order to produce high directional diffusity with specularly reflecting walls a slight departure from the rectangular form could be an advantage, and that it is a disadvantage to locate the source in a corner or recess. The best results were obtained with irregularly reflecting walls; in this case no considerable influence of the form of the room was found. If a part of the wall area was absorbing, a simple relation between the size of the absorbing area and the directional diffusity was only given if the rest of the walls were reflecting irregularly.

From author's summary

3722. Schroeder, M. R., Methods for the measurement of diffusivity in large rooms (in German), *Acustica* **9,** 1, 256–264, 1959.

In two earlier papers it was shown that a number of quantities that could be measured in a room, acoustically, were either not at all, or but loosely, related to the diffusion of the sound field. This paper attempts to make a constructive contribution to the measurement of diffusion. The diffusion is defined as the angular distribution of sound energy flux, in accordance with the definition that has found its visible expression in Meyer's and Thiele's "sound-hedgehog". The problem is how, with sufficient angular accuracy and without disturbing the sound field noticeably, to make measurements in a reverberation chamber, the linear dimensions of which are comparable to the wavelength. It is solved by spectral analysis of the sound field at the measuring wall. The angular accuracy attained by this method is equivalent to that of an area antenna the dimensions of which considerably exceed those of the measuring wall. From author's summary

3723. Czarnecki, S., Spectral analysis of acoustic waves in the transitory regime in a closed chamber (in French), *Acustica* **8,** 5, 291–295, 1958.

The purpose of this work is to analyze the influence of a number of sound sources on the frequency spectrum of an acoustic wave in the transitory regime. In the second part it is shown that the irregularity of the sound decay in a room has also an influence on the frequency spectrum in the transitory regime.

From author's summary

3724. Lubcke, E., Frequency evaluation of sound spectra (in German), *Acustica* **9,** 1, 243–246, 1959.

In experiments on noise the sound spectrum is often a factor in estimating the loudness. The curves used for frequency evaluation are discussed and a method suggested of grouping noises into a definite scale. In practice, according to recent research on the subjective evaluation of objectively equally intense sounds, one should favor such a scale of noise for practical purposes.

From author's summary

3725. Chesterman, W. D., Clynick, P. R., and Stride, A. H., An acoustic aid to sea bed survey (in English), *Acustica* **8,** 5, 285–290, 1958.

A description is given of a rapid acoustic method of charting the small-scale topography and defining patches of different com-

position of a large area of shallow sea floor. It is shown that the procedure is complementary to such conventional methods as physical sampling and echosounding and has important biological applications. From authors' summary

3726. Lutsch, A., An apparatus for measuring and recording the velocity of sound and temperature versus depth in sea water (in English), *Acustica* **8**, 6, 387-391, 1958.

Two crystals are placed opposite each other at a fixed distance in water. The first crystal transmits a short ultrasonic pulse. This pulse is received by the second crystal. The generation of the $(n + 1)$ pulse is triggered by the (n)th received pulse. The resulting repetition frequency is automatically recorded. Multiple reflections in the water path are avoided by impedance matching at the backs of the crystals. The carrier frequency is 1 Mc/s, the relative accuracy is 0.03%. Alternately also the temperature can be recorded by means of a thermistor bridge. The records were made on an X—Y recorder in which the X coordinate is the depth, measured by a pressure gage in a bridge, while the Y coordinate is alternately the velocity of sound or the temperature. Values were recorded to depths up to 30 m. The response time is a few seconds. From author's summary

3727. Schreiner, J., Measurement of ultrasonic sound intensity with a heated wire (in German), *Acustica* **8**, 5, 303-307, 1958.

A survey of the literature shows that no clear picture can be derived from the publications known so far on the relations between sound intensity and the nonperiodic change of resistance of a preheated wire due to cooling.

In order to make use of the hot-wire in absorption measurements with the ultrasonic interferometer, calibration measurements were carried out at 287.75 kc/s in dry carbon dioxide. As a measure for the sound intensity the electric input power of the quartz transmitter was determined by directly measuring current, voltage and phase with the help of a cathode ray oscilloscope. Over a range of lower intensities—broad enough for experimental purposes—a linear relation between the sound intensity and the change of voltage at the hot-wire was found. It is, however, proved that this simple relationship makes the hot-wire unsuited to measure the sound absorption with the interferometer. At higher intensities no simple relationship was found.

From author's summary

Micromeritics

(See also Revs. 3308, 3366, 3464)

3728. Slesser, C. G. M., and Deans, R., Estimation of particle size: an improved Werner sedimentation apparatus, *J. Appl. Chem.* **10**, 2, 62-65, Feb. 1960.

Methods of particle-size determinations based on Stokes' law have inherent inaccuracies. A modified Werner apparatus is described for which it is claimed a mean particle size may be evaluated to ± 2%. Experimental results are given.

From authors' summary

3729. Vidmajer, A., and Brenner, R., Principles and methods of powder statistics (in German), *Radex Rundschau* no. 6, 734-760, 1959.

Basic concepts of powder statistics are mathematically defined by generalized functions: particle properties; powder properties; sums of properties of powder functions; location and magnitude of the peaks of distribution functions; arithmetic mean of particle properties; scattering of particle properties about their mean value; geometric mean of particle properties; distribution of powder properties for the grain-size groups; spread of powder distribution; fineness or dispersity of powders, fineness of size, area, and volume; substitute distribution functions; function parameters; range of validity of powder statistical data. The two most frequently used distribution functions, the Rosin-Rammler exponential function and the Gauss logarithmic function, are defined and mathematically interpreted. The mathematical concepts mentioned above for the generalized function are then applied to these two specific distribution functions, and given a mathematical interpretation.

This is a rigorous, detailed treatment of the mathematics of particle-size distributions, in which every step is based on the preceding one and fully explained. K. J. DeJuhasz, USA

3730. Rammler, E., On the development of the calculation of surface area of RRS-distributions (in German), Freiberger Forschungshefte no. A50, 5-47, Sept. 1956.

The Rosin-Rammler-Sperling (RRS) formula for the grain-size distribution of particulate materials is an exponential function with two parameters, expressing the percentage of residuum as a function of the characteristic linear dimension of the particle. From this basic function, by mathematical operations, various other relations can be derived, i.e., for each grain size: the number percentage, the surface area, the volume, and weight. These relations have been investigated by numerous authors, using various assumptions for the lower and upper limits of grain size, and various mathematical refinements, simplifications, and methods (e.g., expansions into series, numerical tables, and graphic charts) whereby the computational labor can be reduced. Author points out the importance of minimum significant grain size which is chosen as the lower limit of integration, regarding which experimental research is needed. Reference is made to work of Kiesskalt, Anselm, Matz, Weidenhammer, Stange, Kneschke, Langermann, and Puffe. K. J. DeJuhasz, USA

3731. Nassenstein, H., Practical execution of analysis of disperse systems (in German), *Chemie-Ingenieur-Technik* **29**, 92-104, 1957.

Author refers to previous work [Nassenstein, *Chemie-Ingenieur-Technik* **26**, 661-667; **27**, 535-542 and 787-794] describing existing methods of dispersoid analysis, in particular the "Dispersometer" (manufactured by W. and H. Brandt, Bochum-Dahlhausen, Germany). He describes recent development of Dispersometer for automatic counting of photographs of disperse systems, discusses error sources, estimates magnitude of errors, and gives examples to explain method of counting and evaluation. Instrument is claimed to be suitable for counting out optical and electronic microphotographs, even of irregularly shaped particles.

Instrument comprises three main elements: (1) the feeler device comprising a glass cylinder upon which the photograph is mounted; the images of particles are projected on (2) a photoelectric grid; the impulses of the latter are received by (3) the electronic counting unit. All these elements are illustrated and described, their function explained, and error sources discussed. Practical tips are given for obtaining clear images of drops, dusts, and other comminuted particles. Distribution curves for length can be transformed into distribution curves of surface area and of volume. A three-dimensional model is shown representing the history of grain distribution varying in time. Possibilities of improvements are discussed, such as increasing the scanning speed by using transistors instead of electromechanic relays, and measuring the particles in two mutually perpendicular directions.

K. J. DeJuhasz, USA

3732. Schlipkoter, H.-W., Steiger, H., Esser, H. F., and Beck, E. G., Electron microscope investigations of mine dusts using membrane filters (in German), *Staub* **19**, 9, 320-322, Sept. 1959.

Article points to the difficulties of the microscopical analysis of finest dusts and describes a method for the transfer of the dust precipitated on membrane filters onto electronic microscope slides. This simple method has stood the test with the analysis of dustladen air underground and above ground. Several examples are cited and discussed. From authors' summary

3733. Ioos, E., The settling balance (in German), *Staub* **19**, 11, 392–398, Nov. 1959.

An automatically recording balance is described for the deposit of sediment from a column. The reliability of such an instrument is discussed for determining grain-size analyses, particularly in view of possible density currents in the fluid.

H. A. Einstein, USA

3734. Troesch, H. A., Breakup of liquids and determination of drop size (in German), *Chemie-Ingenieur-Technik* **30**, 10, 667–672, 1959.

In this brief survey of the requirements of various industrial, medical and other spray applications, various modes of droplet generation are discussed, i.e., by free fall, separation by jet breakup, separation by jet-wave formulation, and by forced atomization. The first three occur at comparatively low pressure and velocity, and are amenable to experimental and theoretical analysis and to prediction of their characteristics; the fourth mode, atomization at high pressure and velocity, while technologically of the greatest importance, is difficult to investigate experimentally owing to the rapidity of the phenomenon, and it is not possible to predict the characteristics of the spray from the design data of the nozzle and from the properties of the liquid and of the air.

To be usable for the predetermination of drop size and drop-size distribution an experimental procedure must satisfy several requirements, namely: (1) the atomization must be unhindered by foreign bodies and by air currents, and it must be a continuous process; (2) at the location where the drops are collected, their velocity must be low enough so that the drops once formed do not break up further, and the globules do not deform; (3) the sample obtained must be a truly average and representative one; (4) the droplets or frozen globules must not be hollow; (5) the method must yield representative results; (6) between the atomization and the drop-size determination no evaporation of a component of the droplets should occur.

From the aspects of these requirements, author scrutinizes a number of methods used by previous investigators, i.e., various catching methods, spark photography, light absorption, photoelectric methods, and using a substitute material which is liquid when sprayed and is solidified when it is examined. He describes in detail his method of using wax as substitute material, the safeguards to observe for obtaining accurate and reproducible results, as developed in the laboratory of the Nestle Company. Procedure is outlined for evaluating and representing the results in such a manner that these results can form the basis for the rational design of spray-generating equipment.

This is an excellent critical survey giving an up-to-date list of the various methods used for the determination of the fundamental characteristics of sprays. K. J. DeJuhasz, USA

3735. Hagerty, W. W., Yagle, R. A., and El-Saden, M. R., The design of pressure-atomizing swirl-chamber spray nozzles, WADC TR 56–472, 31 pp., Feb. 1957.

Paper presents information for the design of pressure-atomizing spray nozzles, mainly for the range and conditions of turbojet engines. Nozzles of the simple swirl-chamber type, and of the dual-flow type, with positive and negative axial flow are considered. Nozzle performance is given in terms of nozzle geometry, and of physical properties of the sprayed liquid. Theory of such nozzles is reviewed; theoretical prediction and actual performance are compared to show the extent of agreement for a given range. A sample design is worked out to illustrate the use of the equations and data. Design relationships are presented analytically and graphically: (1) pressure drop versus flow rate; (2) cone angle; (3) drop size for various conditions.

K. J. DeJuhasz, USA

3736. Gordon, G. D., Mechanism and speed of breakup of drops, *J. Appl. Phys.* **30**, 11, 1759–1761, Nov. 1959.

Paper presents mathematical analysis of the break-up of liquid droplets in an air stream. Analysis provides an understanding of the variables affecting secondary atomization, i.e., it is directly applicable to case where acceleration of the drop is steady and uniform, in which case the drop flattens, becomes bowl-shaped, inflates like a parachute and finally bursts (see W. R. Lane, *Indust. Engng. Chem.* **43**, 1312–1317, 1951). Author assumes a simplified model in which he estimates the forces acting when a cylindrical plug is extruded from a drop. Resulting equations can be shown to relate critical size and break-up time to the dimensionless Weber ($d\rho_g V^2/\sigma$) and viscosity ($\mu/(\rho_d v d)^{1/2}$) groups. Although a number of broad assumptions are made in deriving equations, the predicted results show agreement within a factor of two with available experimental data. Results corroborate Lane's experimental observations as to the effect of surface tension and viscosity on critical size and break-up time.

T. W. Hoffman, Canada

3737. Kuhn, W., Majer, H., and Burkhardt, F., Velocity of spontaneous breaking up of liquid cylinders into small spheres (in German), *Z. Elektrochemie* **63**, 1, 70–74, 1959.

Previous work [Kuhn, "Spontaneous breakup of liquid cylinders into small spheres," *Kolloid-Z.* **132**, 1–2, 84–99, 1953] showed that a stretched liquid cylinder, acted upon by surface tension, can contract into one single sphere, and also can break up spontaneously into a number of smaller spheres. The breakup of the cylinder into spheres is first initiated by heat effect, then the initial constrictions are completed into total separation by interfacial tension. The times of these two periods have been calculated, and in present research have also been measured experimentally.

A filament of oligostyrol has been stretched out in a water-methylcellulose solution which had the same density as the filament (to eliminate the force of gravity). In the experiment, a thin layer of oligostyrol was poured into a glass cup where it settled on the bottom; then over it a 16% water solution of methylcellulose was poured. Dipping the tip of a glass rod into the oligostyrol and pulling it upward, a filament of about 10-cm length was produced; then the glass rod was fastened into a fixed position. From this instant onward, the time was measured for the filament, fastened at both ends, to break into droplets. This took long enough for the thickness of the filament to be measured by means of a telescope fitted with an ocular micrometer.

The experiments substantiated the proportionality of the breakup time with the diameter of the filament, but the time was far less than the value calculated on the assumption of a perfectly smooth and round filament. An attempt is made to explain this discrepancy by (1) the effect of tension and compression instead of purely Poiseuille flow, and (2) energy fluctuations based on the Maxwell-Boltzmann principle; but these account for only a small part of the discrepancy. K. J. DeJuhasz, USA

3738. Crosby, E. J., and Marshall, W. R., Jr., Effects of drying conditions on the properties of spray-dried particles, *Chem. Engng. Prog.* **54**, 7, 56–63, July 1958.

Relation of size and density of spray-dried particles to the initial size of spray drops is represented in charts, using as

operating variables: air temperature, feed temperature, and feed concentration. Three materials were used: sodium sulfate (a true solution), coffee extract (a colloidal suspension), and a clay slip (a fine slurry). The dried particles obtained were classed as crystalline, amorphous, and fine agglomerates. Operating data for the three materials are tabulated and fully discussed. Photomicrographs show the physical structure of particles, and indicate why the density of spray-dried particles varies inversely with the particle dimaeter.

Authors discuss rate of heat- and mass transfer and explain the drying cycle of droplet, i.e., the formation of a rigid or semirigid surface structure, followed by the removal of the remaining moisture. Particle properties can be predicted to some extent on the basis of the equation of Charlesworth and Marshall, but the actual properties show appreciable difference because the equation is based on zero relative velocity, which implies a lower rate of evaporation than actually occurs.

K. J. DeJuhasz, USA

3739. Lowell, H. H., Free fall and evaporation of JP-4 jet fuel droplets in a quiet atmosphere, NASA TN D-33, 28 pp., Sept. 1959.

Author states: "In connection with the problem of the dispersion of jet fuel jettisoned at altitude, an analytical investigation has been made of free fall with and without evaporation in a quiet atmosphere of JP-4 fuel droplets of average composition. The significant physical characteristics (vapor pressure, etc.) of the droplets were approximated by replacing the chemically complex fuel by a mixture of ten petroleum "fractions" having predictable evaporation rates.

"As in a previous study [NACA RM E53L23a] of the free fall and evaporation of aviation gasoline droplets, it was found that temperature was the principal controlling variable; initial evaporation rates increased by factors of 15 or more as sea-level temperature increased from −30 to +30C. Variations of initial altitude affected mass losses by only a few percent."

A step-by-step computation procedure in time was used. For each interval the motion was calculated using empirical drag for a drop with zero evaporation. Then the evaporation was estimated on the basis of that motion. These two calculations provided initial data (on position, velocity and drop properties) for the next time interval.

S. Corrsin, USA

Porous Media

(See also Revs. 3364, 3368, 3466, 3594, 3595)

3740. Wooding, R. A., The stability of a viscous liquid in a vertical tube containing porous material, *Proc. Roy. Soc. Lond.* (*A*) **252,** 1268, 120–134, Aug. 1959.

The stability of a viscous liquid in a vertical tube containing a porous material (such as randomly packed glass spheres) has been investigated (at Cambridge Univ.). It is assumed that a density gradient exists in the fluid which is due to a concentration gradient with regard to a dissolved substance ("solute"). The diffusivity of the solute through the saturated porous medium is taken into account. A limiting density gradient is derived beyond which stability is not possible. This is done by writing down a modification of Darcy's law (containing time-dependent terms) as the equation of motion of the fluid, the continuity equation and an equation for the diffusion of the solute. This yields a system of differential equations which always possess an equilibrium (no-motion) solution. Its stability is analyzed by the well-known method of superimposing disturbances upon the equilibrium solution and analyzing the behavior of these disturbances with time.

A. E. Scheidegger, Canada

3741. Albert, P., and Jaisson, J., Study of radial flow in a closed reservoir of variable horizontal permeability (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liquid* **14,** 4/5, 560–588, Apr./May 1959.

Oil in a natural circular reservoir under pressure is pumped from a small diameter well at the center. Reservoir has permeabilities homogeneous vertically and heterogeneous horizontally, with the most porous and permeable media at the center and the least at the outer boundary. Predicting the life of the well is economically important. Variables are rate of yield, pressure, extent and permeability of media, compressibility of the oil. The rate of pumping is equated to the rate of expansion of the oil toward the well by means of the Laplace continuity equation and D'Arcy's law. The differential equations are solved both numerically and by IBM. Curves of the solutions are given. The assumptions are bold, but comparison of the analytical conclusions with field performance is well within acceptable limits of seepage estimation.

K. N. Hendrickson, USA

3742. Juhasz, J., An investigation into percolation (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24,** 3/4, 347–377, 1959.

The described computation method is applicable to any two-phase percolating movement in the linear range of seepage.

The essential feature of the method is the introduction of the static friction coefficient physically justified also for water. Fundamental changes in the picture formed about percolation were the result, and determination of the momentary water-conveying cross section of any soil became thereby possible. The new method has yielded an extended form of the classical velocity formula derived by Hagen-Poiseuille.

A very simple Slichter's number was used in deriving the formula. The value of the static friction coefficient α, determined after estimating orders of magnitude by trial and error, was found to be $3 \cdot 10^{-11}$.

Soil characteristics are represented in the formula by the effective particle size, the void ratio and the hygroscopicity by Mitscherlich, while from among those of water, viscosity and pressure are included. The permeability coefficient by Darcy cannot be accepted as a soil characteristic for the new method, it being linked to particle size, as well as to porosity, to physical and chemical conditions of the soil (variations in hygroscopicity) and to both viscosity, pressure and gradient of water.

A representative picture about physical conditions occurring in the range of micro-seepage is presented by the method of active cross sections. The existence of a limit gradient increasing with water pressure is established up to which no movement takes place in the layer in question. A method is offered for computing the active cross section which decreases rapidly at very low gradients and, owing to which, the amount of percolating water is but a fraction of that computed by the Darcy law.

A different light is thrown also on upward capillary movement if the active cross section is taken into consideration.

From author's summary

3743. Schachtmann, Yu. M., The inflow of a liquid to an isolated vertical interstice containing a filler (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 146–149, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10114.

The problem is investigated of the outflow of a two-dimensional, perfect and incompressible fluid of infinite extent, in a homo-

geneous, porous stratum, through a narrow crevice filled with a medium in which the flow obeys Darcy's law. Disregarding the transverse dimensions of this interstice, author reduces the problem under examination to the determination of the complex flow velocity $dw/dz = v_x - iv_y$, which is an analytical function everywhere in the region of the flow, and the real part whereof satisfies, at the sides of an interstice of finite length along the real axis, the following boundary condition:

$$\frac{k'}{k} b \frac{\partial v_x}{\partial x} = \pm 2v_y \quad \begin{array}{l}\text{(positive for } y = +0)\\ \text{(negative for } y = -0)\end{array} \qquad [1]$$

where k, k' are the coefficients of permeability of the stratum and the filling medium of the interstice, respectively; b is the width of the interstice (crevice). Applying conformal transformation to the region of flow, the boundary problem [1] becomes identical with the analogous boundary problem of the exterior of a unit circle. The latter solution can be obtained by trigonometrical Euler series, as developed by Glauert ["Fundamentals of aerofoil and blade theory," Gostekhizdat, 1930], and by V. V. Golubev ["Lectures on aerofoil theory," Gostekhizdat, 1949]. This method enables an approximate solution of Eq. [1]. The convergence of this method in the case of Eq. [1] is not demonstrated by the author. Putting the pressures at the edges of the interstice, and on the periphery of a particular circle sufficiently distant from the interstice, and applying the solution obtained, author derives an expression for the total volume of flow of the fluid entering the interstice. It should be remarked that, in the solution as obtained by the author, the velocity at the boundary of the interstice becomes infinite.

G. N. Pyikhteev
Courtesy Referativnyi Zhurnal, USSR

3744. Abasov, M. T., and Dzalilov, K. H., The inflow of a liquid to an incomplete interstice in an inhomogeneous stratum (in Azerb.), *Meruzeler AzerbSSR Elmler Akad.* **13**, 1, 21-26, 1957; *Ref. Zb. Mekh.* no. 9, 1958, Rev. 10116.

The method originally proposed by G. A. Grünberg ["Memorial on the 70th birthday of Academician A. F. Joffe, Moscow, Izd-vo Akad. Nauk, SSSR, 1950] for integrating differential equations is applied to the solution of the problem of the inflow of a homogeneous liquid to an imperfect interstice in an inhomogeneous circular stratum consisting of two seams of different permeability, k_1 and k_2, and finite thickness. The drainage of the liquid is constant. The roof and floor of the stratum are impermeable. The integration is performed on the assumption that the potential gradient on the draining surface of the interstice in the stratum is constant, and is thus reduced to the solution of the Dirichlet-Neumann boundary problem (at the stratum boundary, the potential is constant). The effective potential at the face of the bore is assumed to be the weighted mean value of the potential obtained in the above manner. Allowance for inhomogeneity is made by applying corresponding conditions for the potential and the potential gradient at the interface of the seams, the thickness of the upper seam being assumed equal to the length of the interval of exposure of the stratum. The final equation of the potential is obtained in the form of an infinite series of the products of Bessel and trigonometric functions. This expression embraces the boundary cases of inflow to an incomplete interstice (bore) in a homogeneous stratum, and of inflow to a complete interstice in an inhomogeneous stratum. It is pointed out that repeated application of the Grünberg method to the integration of the differential equation of the elastic state can also solve the problem of the unsteady inflow of a homogeneous liquid to an incomplete interstice in an inhomogeneous stratum.

A. L. Kheun
Courtesy Referativnyi Zhurnal, USSR

3745. Ollos, G., The effect of irrigation and drainage canals on the ground water level (in Hungarian), *Hidrologiai Kozlony* **39**, 2, 123-139, Mar. 1959.

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 3417, 3441, 3443, 3460, 3530, 3601, 3657, 3701, 3725, 3726)

3746. O'Keefe, J. A., IGY results on the shape of the earth, *ARS J.* **29**, 12, 902-904, Dec. 1959.

This paper summarizes results of tracking data from IGY satellites on the relative positions of the American and Eurasion Continents and the shape of the Earth. It was discovered that Earth was not an oblate sphere but rather slightly pear-shaped, with a bulge on the southern hemisphere. This discovery will affect terrestial guidance, and precision space trajectories.

R. J. Mindak, USA

3747. Harris, C. M., and Kirvida, L., Observation concerning the attenuation of elastic waves in the ground, *J. Acoust. Soc. Amer.* **31**, 7, 1037-1038 (Letters to the Editor), July 1959.

Book—3748. Davydov, L. K., and Konkina, N. G., General hydrology [Obshchaia gidrologiia], Leningrad, Gidrometeoizdat, 1958, 488 pp. $2.40.

Standard textbook for students of geography covers oceans and seas, ground water, rivers, glaciers, lakes, marshes. The great amount of information from all fields of hydrology impresses the reader. About 200 figures illustrate the text.

S. Kolupaila, USA

Book—3749. Netherlands Engineering Consultants, River studies, Amsterdam, North-Holland Publishing Company, 1959, ix + 1000 pp. + 2 maps.

Luxuriously printed report of a group of Dutch engineers, under leadership of H. C. Frijlink, on exploration of the rivers Niger and Benue in Central Africa contains conditions of investigation, equipment and methods applied; description of rivers, their physiography, geology, hydrology; transport and navigation, defects of navigability, recommended improvements. Dutch scientists must be commended for excellent work done under difficult and unusual conditions. Along with the most modern methods applied, the current meter for velocity measurement was rejected as too vulnerable under existing rough conditions. An old device, pendulum, introduced in 1690 by D. Guglielmini, was redesigned by the Delft Hydraulic Laboratory and successfully applied for Niger discharge measurements.

Interesting nomogram of stage-discharge relations was prepared for easy comparison of different gaging stations. Many theoretical considerations and results of laboratory tests are included to illustrate this pioneer report. Suggestions for river improvement by recurrent dredging and by other means are of particular practical importance for the new state of Nigeria. A lucid glossary of terms concludes this interesting volume.

S. Kolupaila, USA

3750. Vantroys, L., Formal structure of the tidal equation (in French), *Houille Blanche* **14**, 5, 533-544, Aug. 1959.

The tidal equations, subject to usual small amplitude, shallow water assumptions, are considered. Equation for tidal amplitude in its hyperbolic form leads to a definition of the characteristic velocity $(gh)^{1/2}$ and the group and phase velocities. Omitting friction and generating forces, and regarding the vertical component of

earth's rotation as constant, some doubly-modulated progressive waves are classified.

Considering a single harmonic in the time reduces the equation to the elliptic form, and author discusses several methods of solution retaining tide-generating potential: the use of Green's function, Proudman's auxiliary functions leading to a Fredholm integral equation, treatment as a problem in the calculus of variations. No particular problems are solved. J. N. Hunt, England

3751. Bonnefille, R., The generalization of Vantroys' similarity laws allowing for variations in the depth of the sea (in French), *Houille Blanche* **14,** 5, 547-555, Aug. 1959.

Vantroys showed that suitable scaling laws enable motion in constant-depth ocean with friction varying linearly with velocity to be represented in a non-rotating model in which Coriolis forces are neglected. Present author shows that, in representing a variable-depth ocean, complex scaling laws arise, and that in the particular case of a conformal mapping of the earth's surface on to a model, the variable depth must satisfy a certain differential equation depending on the mapping function, so restricting the use of such scaling laws.

Reviewer feels that a discussion of the physical significance of complex functions as scaling laws would have been helpful.

J. N. Hunt, England

3752. Timonov, V. V., and Zhukov, L. A., The dynamic method as a research tool in the study of ocean currents (in Russian), *Meteorol. i Gidrologiya* no. 5, 50-55, 1956; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9885.

Detailed qualitative considerations are presented in favor of using dynamic methods in the study of marine currents. It is observed that the introduction of geophysical (electric or magnetic) prospecting methods gives increasing importance to the dynamic study of ocean currents, since they afford a convenient means of measuring surface drifts. If the drift current is known, dynamic analysis will determine the corresponding true current flow at any depth. It is underlined that the dynamic method still needs intensive experimental investigation, and the results obtained by this analytical method compared with the results of direct measurements. Examples of such comparisons are given. The method developed by M. M. Somov is also discussed, in which the current flow is determined by reference to the (sea) bottom. It is pointed out that the latter method contains an inconsistency in that the work of the Coriolis forces is expressed in the same manner as in calculating currents by reference to the zero isobar. It is demonstrated that Somov's method is founded on the propositions of the dynamic method. A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR

3753. Reid, R. O., Effect of Coriolis force on edge waves: Part I, Investigation of the normal modes, *J. Mar. Res.* **16,** 2, 109-144, 1958.

It is shown analytically that two classes of free edge waves can exist on a sloping continental shelf in the presence of Coriolis force. For small longshore wavelength, fundamental waves of the first class behave like Stokes edge waves. However, for great wavelengths the characteristics of the first class are significantly altered. Waves of the second class are essentially quasi-geostrophic boundary waves with very low frequency and are associated with large vorticity. It is proposed that a hurricane can effectively excite the higher-order edge wave modes in addition to the fundamental, if wind stress is considered.

H. Arakawa, Japan

3754. Kajiura, K., Effect of Coriolis force on edge waves: Part II, Specific examples of free and forced waves, *J. Mar. Res.* **16,** 2, 145-157, 1958.

Modification of edge waves due to Coriolis force is examined analytically in two cases: (1) dispersion of an initial deformation of the water surface; (2) the forced wave due to a moving atmospheric pressure disturbance. In both cases, the larger the scale the larger the effect of Coriolis force. In the northern hemisphere, the initial deformation is split into two free edge waves in which the one moving to the left (facing the coast from the sea) has a larger amplitude than that moving to the right. In the case of forced waves, movement of the atmospheric disturbance to the left is more favorable for exciting resurgent edge waves than movement to the right. H. Arakawa, Japan

Book—3755. Priestley, C. H. B., Turbulent transfer in the lower atmosphere, Chicago, The University of Chicago Press, 1959, vii + 130 pp. $3.75.

This very fresh, comprehensive book on the study of atmospheric turbulence and shearing motion near the ground is by the well-known specialist, Dr. C. H. B. Priestley. Table of contents lists these chapters: Introduction; The eddy flux and its measurement; The shearing stress and the wind profile; Heat convection and the temperature profile; The spectrum of turbulence and the structure of free convection; Theories of buoyant motion; Evaporation; Evolutionary aspects of energy transfer; Bibliography and Index.

Author is chief of the Division of Meteorological Physics, CSIRO, Australia, and this most practical book includes many results from his own group, some of which are hard to locate except in Australia. The difference of mechanism between heat and momentum transport in an unstable atmosphere, the problem of roughness measurement on the ocean surface, and the application of the boundary-layer theory to the problem of air-mass modification, among the various topics, leave the reviewer with a very favorable impression. H. Arakawa, Japan

3756. Coleman, T. L., and Meadows, May T., Airplane measurements of atmospheric turbulence at altitudes between 20,000 and 55,000 feet for four geographic areas, NASA Memo 4-17-59L, 21 pp., June 1959.

3757. Petterssen, S., Heat exchange and weather forecasting, *Proc. Nat. Acad. Sci., Wash.* **45,** 12, 1655-1663, Dec. 1959.

An analysis is made of the direct influence of heat transfer from the earth's surface to the atmosphere on development of motion systems. A case is studied in which cold air moved southward across the Great Lakes during winter, and it is demonstrated that positive vorticity amounting to about 80% of the earth's vorticity was associated with the heating occurring at the surface. A case of cyclone development in the western Atlantic Ocean was analyzed by calculating eddy heat transfer and radiative transfer by well-known simple approximations. Radiative transfer was an order of magnitude smaller than eddy transfer and was not simply related to the motion field. Eddy transfer was largest to the west of the pressure trough. It is concluded that "direct effect of heat sources on the development of motion systems is not spectacular," but it is pointed out that large transfer of heat is closely related to the occurrence of shower phenomena on the one hand or fog phenomena on the other. R. G. Fleagle, USA

3758. Petrenchuk, O. P., Some singularities in the vertical structure of anticyclones (in Russian), *Trudf Gl. Geofiz. Observ.* no. 72, 19-32, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10061.

Paper deals with the investigation of the vertical structure of anticyclones. From analysis of the aerologically and synoptically observed data as well as the results of some approximate calculations, author arrives at the following conclusions:

1. Since the indications of the humidity water in a radiosonde are always highly inaccurate, particularly at low temperatures, and

may even be entirely useless, it is not possible to judge the reasons for the appearance of temperature inversion in anticyclones only from the change in specific humidity with altitude.

2. The descending currents alone cannot cause inversion in anticyclones since for that they would have to reach very high values. (Calculation of the vertical currents has been made by the method given in the "Manual of short-term forecasting," Pt. I, Tsentr. in-ta prognozov, Leningrad, Gidrometeoizdat, 1954, 547 pp.)

3. The structures of the stable layers of winter anticyclones differ considerably from the structures in summer anticyclones, in magnitude of the vertical temperature gradients, position of the lower boundary of the stable layer, and its thickness in height.

4. There is a fairly close correlation between the lower boundary of the stable layer and the depth of the boundary layer; the coefficient of correlation equals 0.85 (the depth of the boundary layer H has been calculated by D. L. Laichtmann's equation

$$H = 2.28\sqrt{\frac{k}{\omega_z}} \qquad (\omega_z = \omega \sin \varphi),$$

where k is coefficient of turbulence, ω angular velocity of the terrestrial rotation, φ geographical latitude of the point).

5. In growing and disintegrating anticyclones, the maximum values of the descending motions are usually observed in or near the central region. With increasing distance from the central region of the anticyclone the descending motions fade and ascending currents appear on the periphery.

6. In growing anticyclones, the descending velocities increase, while in disintegrating anticyclones they decrease, with increasing altitude.

Sh. A. Musaelyan

Courtesy Referativnyi Zhurnal, USSR

3759. Shneyerov, B. E., The question of the influence of heat inflow on large-scale displacements in the atmosphere (in Russian), *Trudi Gl. Geofiz. Observ.* no. 71, 103–111, 1957; *Ref. Zb. Mekh.* no. 9, 1958, Rev. 10080.

Author examines perturbations in a regional flow, caused by irregularity in the heat inflow. Allowance is made for the inflow of heat due to turbulent mixing and condensation. The heat sources associated with condensation are assumed to differ from zero only in a particular layer of finite thickness. In this layer, they are approximated by the exponential function of the altitude. An approximate solution is presented for analyzing the accuracy of wind forecasts.

D. L. Laikhtman

Courtesy Referativnyi Zhurnal, USSR

3760. Dyunin, A. K., The analytical determination of ground-level wind velocities behind permeable snow screens (in Russian), *Izv. Vost. Fil. Akad. Nauk SSSR* no. 1, 95–108, 1957; *Ref. Zb. Mekh.* no. 9, 1958, Rev. 10084.

For the calculation of mean wind velocities behind permeable screens, use is made of the known solutions of the equation of energy in the theory of free turbulence, first suggested by H. Reichardt [*ZAMM* **21**, 1941] and presented in the form

$$\frac{\partial v^2}{\partial(x^2)} = a^2\left(\frac{\partial^2 v^2}{\partial y^2} + \frac{\partial^2 v^2}{\partial z^2}\right)$$

where a is a nondimensional constant determined experimentally. In addition, an empirical formula is presented, developed by A. A. Bogorodetsky ["Wind loads on bridges"; thesis, Moscow, 1946], for the resistance of the screen, with some complementary considerations. The resulting analytical velocity curve is very close to the experimental curve.

N. A. Slezkin

Courtesy Referativnyi Zhurnal, USSR

3761. Kessler, E., III, and Atlas, D., Model precipitation distributions, *Aero/Space Engng.* **18,** 12, 36–40, Dec. 1959.

Paper gives revised distributions of interest, based on a generalized theory of the relationships between air motions and precipitation.

From authors' summary

3762. Allison, F., and Hughes, G., Suggested methods of aligning the planes of the solar furnace heliostat mirrors into parallelism, *Solar Energy* **2,** 3/4, 46–48, July/Oct. 1958.

Naval Architecture and Marine Engineering

(See also Rev. 3395)

3763. Wiegel, R. L., Clough, R. W., Dilley, R. A., and Williams, J. E., Model study of floating drydock mooring forces, *Inter. Shipbldg. Prog.* **6,** 56, 147–159, Apr. 1959.

Authors discuss the problem of wave-induced forces on ships' moorings, together with the details of a laboratory study of an AFDL-1 (floating drydock). The resulting mooring line forces are given. In addition, the correlations between prototype and model natural periods of surge and sway are given.

From authors' summary

3764. Bartsch, H., Statistical methods for the investigation of the movement of a ship on the sea, Parts I and II (in German), *Schiffstechnik* **6,** 30, 1–8, Feb. 1959; **6,** 31, 85–92, Apr. 1959.

Parts I and II form an extensive summary of Berichtes no. 1151 der Hamburgischen Schiffbau Versuchsanstalt. The latter report is a review of the most important theoretical and experimental results on the motion of ships in sea-waves. Part I starts with a description of seawaves by means of the theory of time series. First is treated the motion of the sea surface at a fixed point. Theoretical and practical results for this motion and for its spectral distribution are given. After this the sea wave as a function of time and place (mainly one coordinate only) is considered and expressions are given for the vertical motion of a point which moves with a constant speed. In the final section of part I the influence of the sea waves on the stamping, pitching and rolling of a ship is shown; the spectral distribution for these motions are discussed and compared with experimental results.

In part II some derived quantities of the vertical motion at a fixed point are studied, e. g. the distribution of the zero's, of the maxima and minima, of the wave amplitudes and the wave tops. Again theoretical and practical results are given.

The papers give a good review of the statistical theory of sea waves and ship motion from an engineering viewpoint and they may serve as a good introduction for further study on this subject if the main parts of the theory of time series is known.

J. W. Cohen, Holland

3765. Radosavljevic, L. B., Criterion for neglecting free oscillations of a ship in a seaway, *Inter. Shipbldg. Prog.* **6,** 56, 141–146, Apr. 1959.

Author describes a mathematical criterion for neglecting the free oscillations of a ship in a seaway. The problem is reduced to two simultaneous linear nonhomogeneous second-order differential equations with constant coefficients. Because of system damping, the general solutions of homogeneous parts of the equations have an amortizing character enabling the engineer to neglect the free oscillations and thus to reduce the problem to that of forced oscillations.

C. B. Matthews, USA

3766. Golovato, P., A study of the transient pitching oscillations of a ship, *J. Ship Res.* **2,** 4, 22–30, Mar. 1959.

By means of the free oscillations technique, experimental results were obtained for the amplitude decay versus time of a model ship constrained to pitch about a transverse axis at the intersection of waterplane and midsection. The system response did deviate from that of a simple linear oscillator in two ways, viz. (a) in a semilogarithmic plot the amplitude decay curve was not a straight line, and (b) a distinct difference between the decay of the maximum amplitude values (at even half wavelengths) and that of the minimum amplitude values (at odd half wavelengths) did exist.

Qualitatively the system response is explained by taking into account the effect of the finite length of the wave pattern generated by the oscillating body. Mathematically, this can be done by representing the energy dissipation by a convolution integral, containing a function similar to the Wagner function in unsteady aerodynamics.

It is shown that a good fit to the measured amplitude decay curves is obtained by assuming a certain character of the introduced function. H. Bergh, Holland

3767. Van Manen, J. D., and Crowley, J. D., Some aspects of circulation theory design of screw propellers, *Inter. Shipbldg. Prog.* **6,** 62, 429–443, Oct. 1959.

Design of marine propellers by methods based on circulation theory is more laborious than conventional design practice based on model tests, but allows a better prediction of efficiency and cavitation problems involved. In addition, since there is no need to base the design on the characteristics of a particular series, revisions may be made to meet special requirements. Experience has shown that present circulation-theory design based on moderately loaded propellers does not result in a propeller with correct pitch, and empirical corrections must be introduced to obtain design thrust, under correct rpm and power. Part A of paper discusses pitch discrepancies, experiments made to evaluate these errors, and techniques used to correct them. Part B deals with choice of radial pitch distribution for screws applied to single-screw ships. According to tests in cavitation tunnel it is evident that cavitation-free propellers cannot be designed for single-screw ships. However, a fairly large variation may be made in radial pitch distribution without serious loss of efficiency, thus enabling the designer to minimize the more harmful forms of cavitation. Cavitation tunnel performance of propellers with radial pitch distribution is discussed.

A. Balloffet, USA

3768. Meijer, M. C., Some experiments on partly cavitating hydrofoils, *Inter. Shipbldg. Prog.* **6,** 60, 361–368, Aug. 1959.

A description is given of some experiments on partly cavitating hydrofoils, which were intended to check the linearized theory of Geurst for these flows. The results show good agreement between experiment and theory. The experiments indicate an essential difference between partially and fully cavitating flows, which is described in the paper.

From author's summary by J. W. Ebert, Jr., USA

3769. Mottard, E. J., Hydrodynamic characteristics of a planing surface with convex longitudinal curvature and an angle of dead rise of 20°, NASA TN D-180, 28 pp., Jan. 1960.

A hydrodynamic investigation was made in Langley tank no. 1 of a longitudinally curved planing surface with a dead-rise angle of 20°. The surface was a circular arc with the center of curvature 20 beams above the model. The beam was 4 inches and the length-beam ratio was 9. Wetted length, resistance, and trimming moment were determined for values of beam-load coefficient C_Δ from –3 to 37, Froude numbers from 6 to 25, and Reynolds numbers from 5×10^5 to 10^7.

Compared with a 0°-dead-rise surface with the same curvature, the 20°-dead-rise surface had a greater wetted-length–beam ratio (for the same lift), a lower lift–drag ratio, a more forward center-of-pressure location, and greater trim for maximum lift–drag ratio. Except at very low trim, the variation of the center-of-pressure location with wetted length was about the same for the 20°-dead-rise surface as for the 0°-dead-rise surface. The angle of the heavy-spray line at the wetted leading edge was the same as for a longitudinally straight surface with the same dead rise and leading-edge angle of incidence. The skin friction for the 20°-dead-rise curved surface was nearly the same as that for a plane surface aligned parallel to the stream.

From author's summary

3770. Vaughan, V. L., Jr., A hydrodynamic investigation of the effect of adding upper-surface camber to a submerged flat plate, NASA TN D-166, 22 pp., Nov. 1959.

A hydrodynamic investigation has been conducted to determine the effects of adding camber to the upper surface of a rectangular modified flat plate having an aspect ratio of 0.25 and operating at a constant depth of submersion of 6 inches at noncavitating and nonventilating speeds. Comparisons have been made between these data and data previously obtained on two rectangular modified flat plates having aspect ratios of 0.25 with different thicknesses. These comparisons show that adding camber to the upper surface of a flat plate, which increased the thickness, decreased the angle of zero lift, the lift-curve slope, and the lift coefficients at the high angles of attack. The addition of camber moved the center-of-pressure location rearward with decreasing angle of attack while the center-of-pressure location of the flat plates moved forward with decreasing angle of attack. For a given lift coefficient the lift-drag ratio decreased with increasing camber. The maximum lift-drag ratio moved to higher angles of attack with increasing camber. As the camber on the upper surface was increased, thus increasing the thickness from approximately 7- to 10-% chord, the lift coefficient increased as a linear function of thickness. From author's summary

3771. Johnson, V. E., Jr., and Rasnick, T. A., Investigation of a high-speed hydrofoil with parabolic thickness distribution, NASA TN D-119, 27 pp., Nov. 1959.

Principles of both fully wetted and supercavitating flow theory are utilized to design a thick hydrofoil with acceptable hydrodynamic efficiency in the 100-knot (169 fps) speed range. The hydrofoil design incorporates mean-line camber with a parabolic thickness distribution. A model of the cambered parabolic section with an aspect ratio of 1 and a base thickness of 0.1 chord was investigated at a depth of 0.5 chord for a range of angles of attack from 1° to 8° and speeds from 130 to 190 fps. The results of the investigation showed maximum lift-drag ratios in the 80- to 100-knot (135 to 169 fps) speed range equal to or greater than those obtained on thin supercavitating hydrofoils.

From authors' summary

3772. Wereldsma, R., Model tests for determining critical vibrations of the rudderpost of a "Mariner" rudder, *Inter. Shipbldg. Prog.* **6,** 57, 187–195, May 1959.

In a "Mariner" rudder the major supporting bearing is located about half way down the rudder and is cantilevered from the hull. The bending and torsional vibrations of this rudder under excitation from the propeller have been studied by model tests in a propeller tunnel. To assure that the proper model stiffness, weight and propeller rpm are used, a study was made of the laws of mechanical simularity governing the vibrating rudder system. The tests showed that the random forces acting on the rudder and rudder post are so large and the damping is so small that larger

amplitudes of vibration occurred at the natural frequency of the rudder assembly than at the propeller excitation frequency.

F. E. Reed, USA

Friction, Lubrication and Wear

(See also Revs. 3307, 3361, 3374, 3597)

3773. Glaeser, W. A., and Allen, C. M., A study of design criteria for oscillating plain bearings, *ASLE Trans.* **2,** 1, 32–38, Apr. 1959.

Bearing design data such as is given in this paper should be most beneficial to certain designers. Aluminum bronze for the bearing material and hardened steel for the journal should be a relatively good combination of materials, as was found to be the case. The hardened-steel bearing with the same material for the journal would be expected to be a rather poor combination of materials, although the special chrome plating improved the load-carrying ability of the combination. One might expect the steady-state loads to be more severe that those of the reversing type, again as was found to be the case. The coefficient of friction of about 0.06 looks quite low for the case of a grease-lubricated bearing.

There are many applications where the angle of oscillation may be as small as several degrees instead of 45°. It would be well to have design information for this case also.

Reviewer does not like the use of the term "bearing stress" as it is used in this paper. The term "bearing stress", or stress in the bearing, should be left to mean just what it does mean, namely, the stress in the bearing shell, either tangential, radial, or axial. The term "bearing stress" as used here is nothing but the load per square inch of projected bearing area.

Fig. 5 giving, in effect, load-life and wear characteristics, and the sample problem dealt with, should prove helpful to airframe designers.

E. K. Gatcombe, USA

Books Received for Review

ACEVEDO, M. L., AND MAZARREDO, L., edited by, Proceedings of the 8th International Towing Tank Conference, Madrid, 15-23 Sept. 1957; Madrid, Canal de Experiencias Hidrodinamicas, El Pardo, 1959, 347 pp. (Paperbound)

BATCHELOR, G. K., edited by, The scientific papers of G. I. Taylor, Vol. II: Meteorology, oceanography and turbulent flow, New York, Cambridge University Press, 1960, x + 515 pp. $14.50.

BEYER, R., Kinematisch-getriebedynamisches Praktikum, Lehr- und Ubungsbuch zur graphodynamischen ebener Getriebe, Berlin, Springer-Verlag, 1960, viii + 170 pp. DM 29.40.

BLIZNYAK, E. V., AND YUFIN, A. P., edited by, Hydraulic structures and dynamics of river beds (in Russian), Moskva, Izdatel'stvo Akademii Nauk SSSR, 1959, 242 pp. 13 r. (Paperbound)

BRUN, E., AND MARTINOT-LAGARDE, A., Mechanique des Fluides, Vol. 1, Part 2: Ecoulements a une dimension-conduites, Paris, Dunod, 1959, xxi + 264 pp. 2500 f. (Paperbound)

CHMELKA, F., AND MELAN, E., Einfuhrung in die Festigkeitslehre, 4th ed., Wien, Springer-Verlag, 1960, viii + 369 pp. pp. $7.60. (Paperbound)

CLAUSER, F. H., editor, Plasma dynamics (International Symposium on Plasma Dynamics, Woods Hole, Mass., June 9-13, 1958), Reading, Mass., Addison-Wesley Publishing Co., Inc., 1960, ix + 369 pp. $12.50.

CLAUSS, F. J., edited by, First Symposium on Surface Effects on Spacecraft Materials (sponsored by the Missiles and Space Div. of Lockheed Aircraft Corp. and the Air Research and Development Command of USAF), Palo Alto, Calif., May 12-13, 1959; New York, John Wiley & Sons, Inc., 1960, vx + 404 pp. $11.50.

DUSCHEK, A., AND HOCHRAINER, A., Grundzuge der Tensorrechnung in analytischer Darstellung, Vol. I: Tensoralgebra, 4th ed., Wien, Springer-Verlag, 1960, 171 pp. $5.70. (Paperbound)

D'YACHKOV, A. K., edited by, Development of the hydrodynamic theory of lubrication for thrust bearings (in Russian), Izdatel'stvo Akademii Nauk SSSR, 1959, 152 pp. 7 r. 80 k. (Paperbound)

FOUST, A. S., WENZEL, L. A., CLUMP, C. W., MAUS, L., AND ANDERSEN, L. B., Principles of unit operations, New York, John Wiley & Sons, Inc., 1960, vii + 578 pp. $15.

GOODIER, J. N., AND HOFF, N. J., edited by, Structural mechanics (Proceedings of the First Symposium on Naval Structural Mechanics, Stanford University, Calif., Aug. 11-14, 1958), New York, Pergamon Press, 1960, xi + 594 pp. $9.

GREENSPAN, D., Theory and solution of ordinary differential equations, New York, The Macmillan Co., 1960, 148 pp. $5.50.

HALLIDAY, D., AND RESNICK, R., Physics, for students of science and engineering, Part II, New York, John Wiley & Sons, Inc., 1960, xiv + 471 pp. + appendices. $6.

HARRIS, L. P., Hydromagnetic channel flows, New York, John Wiley & Sons, Inc., 1960, vi + 90 pp. $2.75.

KADEN, H., Wirbelstrome und Schirmung in der Nachrichtentechnik, 2nd ed., (Technische Physik in Einzeldarstellungen, vol. 10), Berlin, Springer-Verlag, xv + 354 pp. DM 66.

KEZDI, A., Talajmechanika, Budapest, Tankonyvkiado, 1959, 618 pp. 63.20 Ft.

LANDAU, L. D., AND LIFSHITZ, E. M., Fluid mechanics, Vol. 6 (Translated from the Russian by J. B. Sykes and W. H. Reid), Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, xii + 536 pp. $14.50.

LANDAU, L. D., AND LIFSHITZ, E. M., Theory of elasticity, Vol. 7 (Translated from the Russian by J. B. Sykes and W. H. Reid), Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, 134 pp. $6.50.

LYKOV, A. V., AND MIKHAILOV, YU. A., Theory of mass and energy transfer (in Russian), Minsk, Izdatel'stvo Akademii Nauk BSSR, 1959, 330 pp. 13 r.

McCUSKEY, S. W., Introduction to advanced dynamics, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, viii + 263 pp. $8.75.

Manual pentru calculul constructiilor, Bucuresti, Editura Tehnica, 1959, 1964 pp. Lei 78.

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